First Year Report

Pecan Hedge-pruning: A Sustainable Management Option for the Southeastern US (LS20-340)

Despite the limitations posed by COVID-19, the research team was able to accomplish several objectives outlined in the proposal. The results summary and discussion are outlined per study area for simplicity.

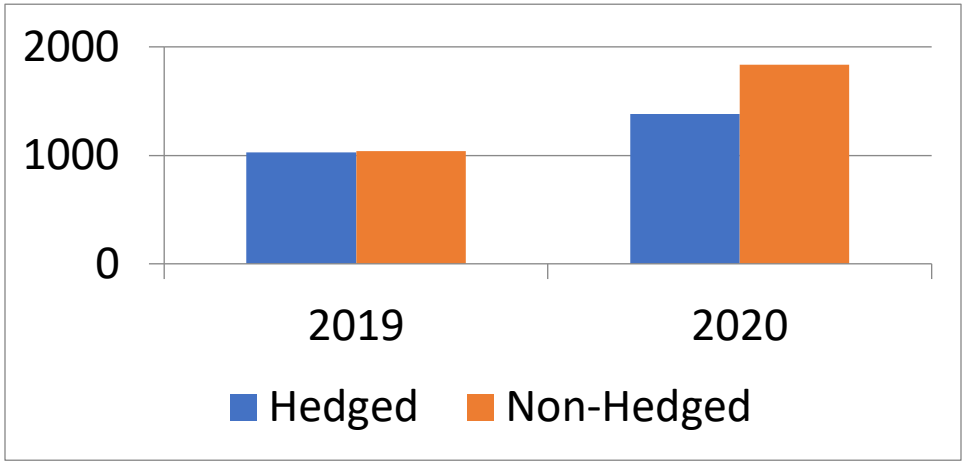
1. **Horticulture (Lenny Well,s UGA)**

There was no statistical difference in yield between hedged and non-hedged trees in 2019; however, in 2020 non-hedged trees produced a higher ($P<0.05$) yield than hedged trees. Nut size (as reflected in a lower number of nuts per lb) was greater ($P<0.05$) in hedged than non-hedged trees during both years of the study. In 2019 leaf potassium (K) was higher ($P<0.05$) in non-hedged than in hedged trees. Hedged trees had higher ($P<0.05$) leaf nitrogen (N) concentration in 2020 than non-hedged trees.

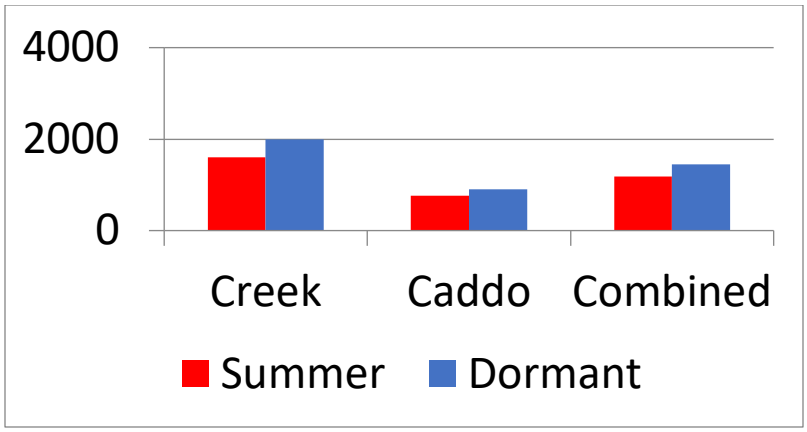
There was no difference between summer hedged and dormant hedged trees with respect to yield.

The timing of hedging influenced leaf nutrient concentration in 2019 but not in 2020. Leaf N was higher in summer hedged trees than in dormant hedged trees in 2019. Summer hedged trees had lower ($P<0.05$) leaf K and leaf zinc (Zn) concentrations in 2019 than did dormant hedged trees.

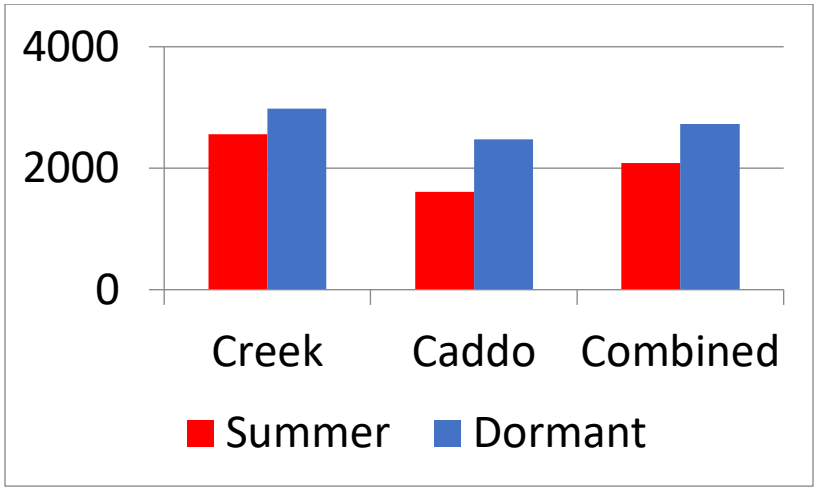
Hedged vs Non-Hedged Yield of 'Desirable' Pecan in 2019 and 2020



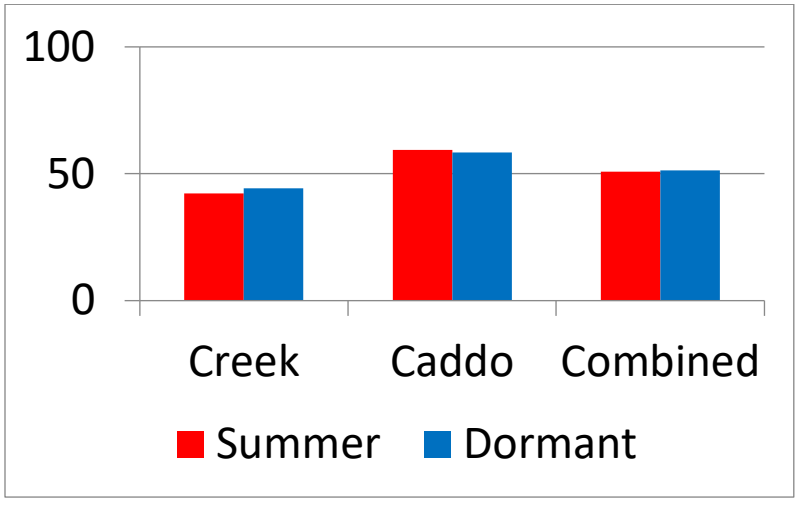
2019 Summer vs Dormant Hedging Yields



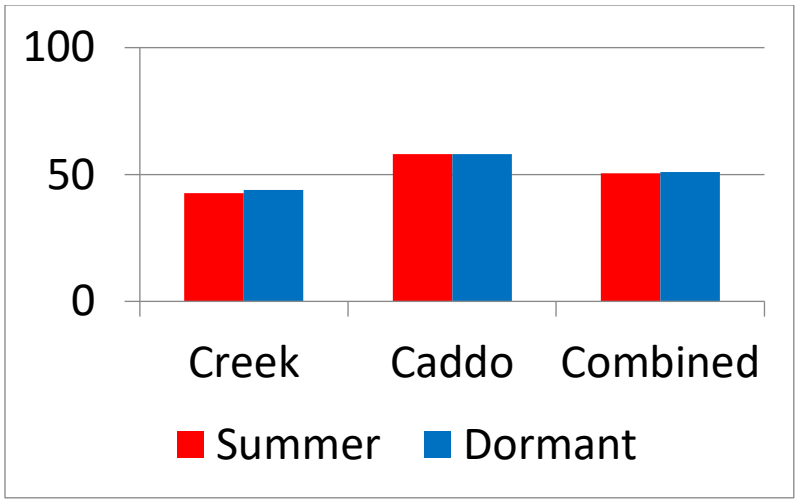
2020 Summer vs Dormant Hedging Yield



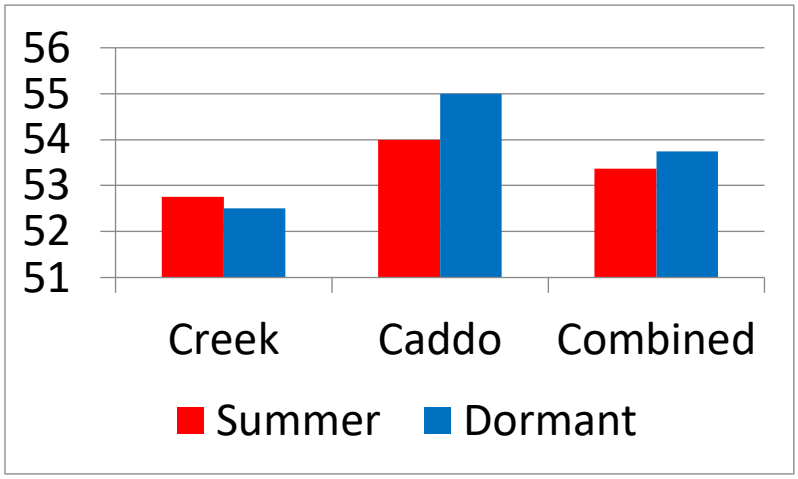
2019 Summer vs Dormant Nuts/lb



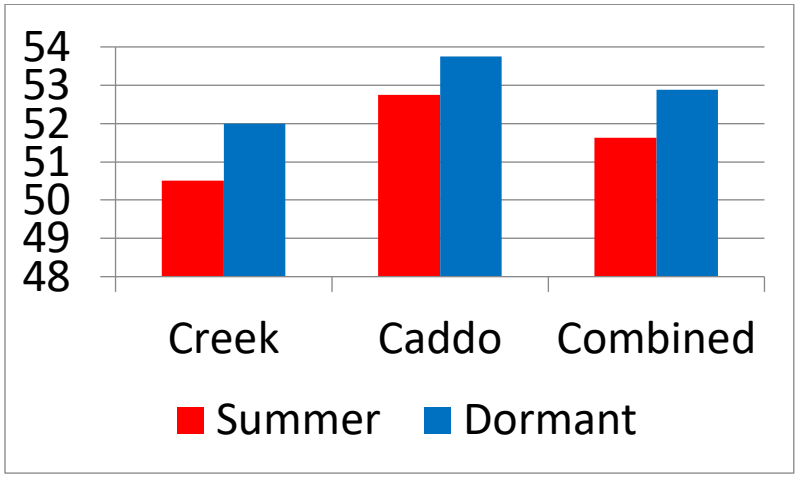
2020 Summer vs Dormant Nuts/lb



2019 Summer vs Dormant Percent Kernel



2020 Summer vs Dormant Percent Kernel



Leaf Nutrient Concentration of Hedged and Non-Hedged 'Desirable' Pecan Trees in 2019 and 2020

Year	Treatment	N	P	K	Zn
2019	Hedged	3.13a	0.12a	1.13a	90a
	Non-Hedged	2.94a	0.11a	1.27b	85a
2020	Hedged	2.91a	0.12a	1.05a	73a
	Non-Hedged	2.76b	0.12a	1.11a	83a

Leaf Nutrient Concentration of Summer and Dormant Hedged 'Creek' and 'Caddo' Pecan Trees during 2019

Treatment		N	P	K	Zn
Time of Hedging					
	Summer	3.2a	0.16a	0.92b	77b
	Dormant	2.9b	0.15a	1.07a	83a
Cultivar					
	Creek	3.09a	0.15a	0.97b	79a
	Caddo	3.03a	0.15a	1.02a	81a
P Value					
	Hedging Time	<0.001	0.30	<0.001	0.01
	Cultivar	0.21	0.51	0.05	0.32
	HT X Ctvr	0.47	0.63	0.83	0.004

Leaf Nutrient Concentration of Summer and Dormant Hedged 'Creek' and 'Caddo' Pecan Trees during 2020

Treatment		N	P	K	Zn
Time of Hedging					
	Summer	2.98a	0.16a	1.05a	80a
	Dormant	2.93a	0.15b	1.00a	76a
Cultivar					
	Creek	2.92a	0.15a	1.03a	86a
	Caddo	2.99a	0.15a	1.02a	70a
P Value					
	Hedging Time	0.49	0.009	0.27	0.71
	Cultivar	0.32	0.28	0.86	0.09
	HT X Ctvr	0.27	0.05	0.39	0.91

2. Plant Pathology (Clive Bock, USDA-Byron)

Objectives:
1) Determine relative impacts of hedge-pruning young and older trees by comparing disease in hedged-pruned and non-pruned young and older pecan trees.
2) Define the effects of timing (summer versus winter) on hedge-pruning of pecans on the variables listed in objective 1.

Materials and Methods:
Four locations with hedge-pruning treatments as follows:

1. Ray City (summer and winter hedge-pruning – all fungicide treated)
2. Marshallville (hedge-pruned and non-hedge-pruned trees – all fungicide treated)
3. Montezuma (hedge-pruned and non-hedge-pruned trees – all fungicide treated)
4. Byron (hedge-pruned and non-hedge-pruned trees – fungicide treated and mon-treated trees)

At all locations, scab assessments were made on leaves and fruit at two points in the season - the first sample was taken when fruit were immature (late June/early July), and the second sample when fruit were mature from mid-August to mid-September. Depending on the experiment, samples were collected at up to 4 heights. Ten compound leaves and ten fruit were collected at each height on both row-sides of each sample tree. Samples were collected using a hydraulic lift at approximately 5-6, 8-9, 11-12 and 13+ m. Sample heights above ground were measured using an Opti-Logic Laser Rangefinder (Opti-Logic, Tullahoma, TN). Leaf samples were assessed for severity of pecan scab based on the percent area diseased was visually estimated on each leaflet of each compound leaf. Scab on fruit was assessed similarly - pecan fruit are comprised of four valves joined along their edges by a suture, and each of the four valve faces was assessed individually for severity of pecan scab based on the percent area diseased. Assessments were aided by standard area diagrams for scab severity on both leaves and for fruit. Fruit fresh weight was determined individually at the time. Fruit weight included the shuck. Shoot samples of the previous seasons growth were collected as for the leaf and fruit samples, but in January 2021. Shoots were measured and the number of scab lesions counted for each shoot. Data are were analyzed using a generalized linear mixed model with fixed effects of treatment, tree height and tree side, and random effects of replicate. Means separation was by Tukey's HSD ($\alpha = 0.05$).
Results and Discussion
We have completed preliminary analysis of two experiments (The Ray City and Marshallville locations). Scab was very mild at the Ray City location (Caddo is only moderately susceptible), while Desirable is very susceptible to scab. Thus, mean scab severity on mature fruit at the Ray City location was <7.0% at all heights, regardless of summer or winter pruning management (Fig 1A). Numerically, there was slightly more sever scab at 5 and 9 m on the summer pruned compared to the winter pruned trees. Severity was numerically less low in the canopy regardless of summer or winter pruning. Despite mostly low severity, scab impacted fruit weight (Fig 1B). On mature fruit at the Marshallville location, mean scab severity was >16% (Fig. 2A). Scab severity was similar at all height in the non-hedge-pruned trees, but in the hedge pruned trees there was significantly less sever scab at 11 m height compared to lower in the canopy, and to the severity in the non-hedged trees. Scab had a profound effect on fruit weight (Fig 2B).

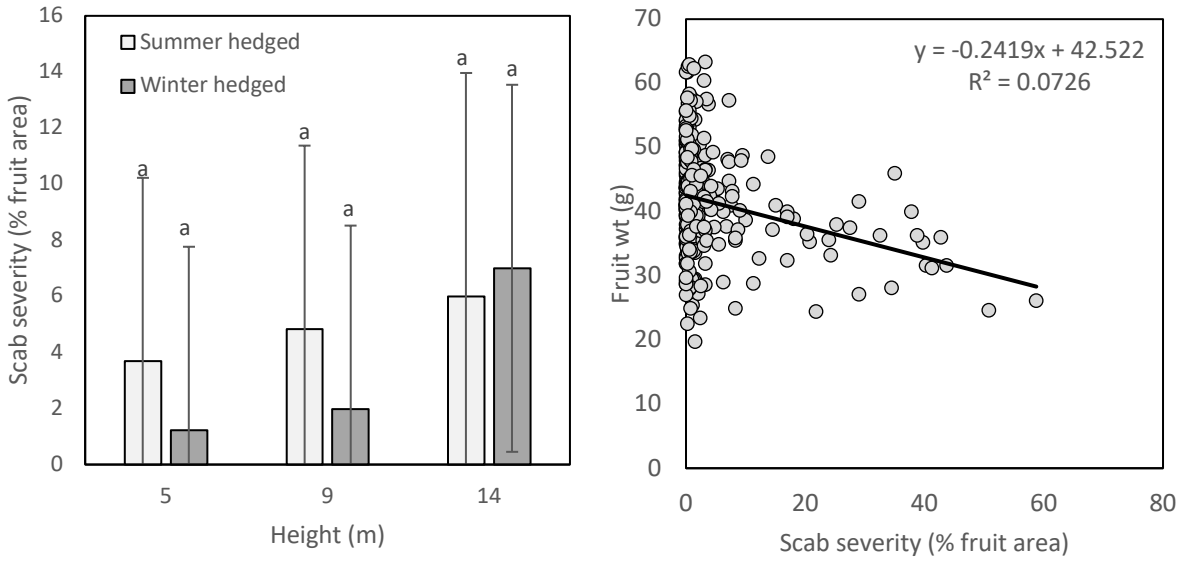


Fig 1.A. Scab severity on mature pecan fruit at different heights in the canopy of mature Caddo pecan trees in an orchard at Ray City, GA. Trees in the orchard received either summer or winter hedge-pruning management. Means with different letters are significantly different based on Tukey's HSD. Error bars indicate 95% confidence intervals. **B.** The relationship between fruit weight and scab severity.

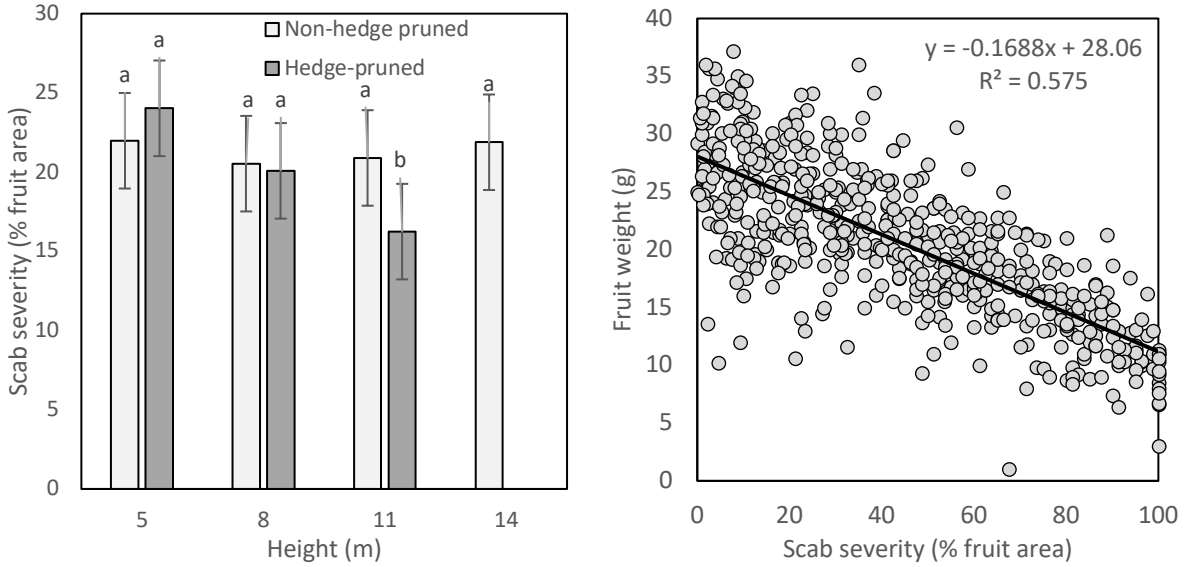


Fig 2.A. Scab severity on mature pecan fruit at different heights in the canopy of mature Desirable pecan trees in an orchard at Marshallville, GA. Trees in the orchard received were either non-hedge pruned or revived winter hedge-pruning management. Means with different letters are significantly different based on Tukey's HSD. Error bars indicate 95% confidence intervals. **B.** The relationship between fruit weight and scab severity.

3. **<u>Entomology (Angel Acebes-Doria and Jason Schmidt, UGA)</u>**
   Objectives:
   1) Determine relative impacts of hedge-pruning *young trees* by comparing pest insect populations in hedged-pruned and non-pruned *young trees*. (Marshallville)
   2) Determine relative impacts of hedge-pruning *older trees* by comparing insect pest populations in hedged-pruned and non-pruned *older trees*. (Montezuma)
   3) Define the effects of timing (summer versus winter) on hedge-pruning of pecans on pest and beneficial insect populations. (Ray City)

Note: The beneficial insect population data are still being processed, hence are not reported here.

Objective 1 Entomology Results: Marshallville

Yellow pecan aphid (YPA) complex population. In June, no significant interaction was found between hedging treatment and canopy location on YPA populations (Table 1: June). The number of YPA's did not differ between the upper and lower canopy but more YPA's were found in the hedged than non-hedged trees (Table 1: June). In July, no significant interaction was found between treatment and canopy location (Table 1: July). There was no significant difference between hedged trees and non-hedged trees but there were more YPA's in the lower canopy than the upper canopy (Table 1: July). In August, there was an interaction between treatment and canopy location, and the upper canopy of the hedged trees had more YPA's than the other three treatment and canopy combinations (Table 1: August).

Black pecan aphid population. There was no interaction effect between the treatment and canopy location in the black aphid populations (Table 2: August). The BPA populations did not differ between hedged and non-hedged trees, however, the upper canopy had significantly more black aphids than the lower canopy (Table 2: August).
Phylloxera galls. In June, there was no significant interaction between the treatment and canopy locations (Table 3: June). There was no significant difference between hedged and non-hedged trees and none with canopy location as well (Table 3: June). In July, there was no significant interaction between canopy location and treatment (Table 3: July). There were significantly more galls located in the non-hedged trees than the hedged trees, but there was no difference between the upper and lower canopies of the trees (Table 3: July). In the month of August, there was no interaction between canopy location and hedged or non-hedged, however the lower canopy had more galls than the upper canopy and non-hedged trees had more than hedged trees (Table 3: August).
Pecan leaf scorch mite population. In August, no significant interaction was found between canopy location and treatment. When individually analyzing canopy location and treatment, there was no significant difference between hedged trees and non-hedged trees but there were more PLSM in the lower canopy than the upper canopy (Table 4: August).
Insect-related nut injury before harvest. Nut samples from June and July with insect-related injuries were very low to warrant statistical analysis. In the month of June, 588 nuts were collected and only 15 had pecan nut casebearer damage (~2.6% infestation rate). In the month of July, 478 nuts were collected, and only 6 had pecan nut casebearer damage (1.25 % infestation rate), and no nuts had shuckworm damage.

Evaluation of insect injury on harvested nuts. Overall, insect-related damage on harvested nuts were low. Of the 435 nuts collected, only 23 had shuckworm damage (5.28% infestation rate) and no stink bug or nut curculio damage was found.

Table 1. Mean number of yellow complex aphids sampled in 2020 from the upper and lower canopies of 25-year old 'Desirable' pecan trees that were hedged and not hedged.

Treatment	Canopy Location	Mean ± SEM No. Total Yellow aphid complex per two leaves		
		June	July	August
Hedged	Upper	2.63 ± 0.52^	3.60 ± 0.84	18.33 ± 3.68 a
	Lower	2.57 ± 0.49^	7.00 ± 1.46*	2.93 ± 1.38 bc
Non-Hedged	Upper	1.58 ± 0.32	2.75 ± 0.25	4.68 ± 1.01 b
	Lower	1.90 ± 0.32	4.80 ± 1.44*	1.48 ± 0.43 c
	Interaction Effects (*P* Value)	0.5962	0.5557	0.0017
	Non-hedged/Hedged (*P* Value)	0.0324	0.1690	0.0002
	Upper/Lower (*P* Value)	0.6965	0.0331	0.0001

Columns with * following the means have a significant higher value between canopy locations using a student t-test.
Columns with ^ following the means have a significantly higher value between treatments
Columns with a letter following the means have an interaction between the canopy location and treatment.

Table 2. Mean number of black pecan aphids sampled in August 2020 in 25-year old 'Desirable' pecan trees from the upper and lower canopies of hedged and non-hedged trees.

Treatment	Canopy Location	Mean ± SEM No. Total Black Aphids per two leaves
		August
Hedged	Upper	3.48 ± 1.07*
	Lower	0.63 ± 0.49
Non-Hedged	Upper	2.58 ± 1.71*
	Lower	0.23 ± 0.10
	Interaction Effects (*P* Value)	0.6441
	Non-hedged/Hedged (*P* Value)	0.3538
	Upper/Lower (*P* Value)	0.0220

Columns with * following the means have a significant higher value between canopy locations using a student t-test.
During the June and July sampling, black pecan aphids were not found on the leaf samples.

Table 3. The mean number of Phylloxera galls per sample taken from the upper and lower canopies of hedged and non-hedged 25-year old 'Desirable' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total *Phylloxera* galls per two leaves		
		June	July	August

Hedged	Upper	0.10 ± 0.07	0.08 ± 0.03	0 ± 0
	Lower	1.15 ± 0.99	0.55 ± 0.46	0.25 ± 0.15*
Non-Hedged	Upper	0.53 ± 0.09	0.55 ± 0.20^	0.68 ± 0.36^
	Lower	1.93 ± 0.49	1.58 ± 0.50^	2.10 ± 1.05*^
	Interaction Effects (*P* Value)	0.8331	0.5250	0.6089
	Non-hedged/Hedged (*P* Value)	0.0643	0.0359	0.0076
	Upper/Lower (*P* Value)	0.0545	0.1120	0.0328

Columns with ^ following the means have a significantly higher value between treatments using a student t-test.
Columns with * following the means have a significant higher value between canopy locations using a student t-test.

Table 4. The mean number of total pecan leaf scorch mites from each sample of 25-year old 'Desirable' pecan trees taken from the upper and lower canopies of hedged and non-hedged trees in August 2020.

Treatment	Canopy Location	Mean ± SEM No. Total Pecan leaf scorch mites per two leaves
		August
Hedged	Upper	2.00 ± 1.44
	Lower	28.20 ± 11.13*
Non-Hedged	Upper	1.13 ± 0.54
	Lower	12.40 ± 4.89*
	Interaction Effects (*P* Value)	0.3132
	Non-hedged/Hedged (*P* Value)	0.2232
	Upper/Lower (*P* Value)	0.0019

Columns with * following the means have a significant higher value between canopy locations using a student t-test.
During the June and July sampling, pecan scorch mites were not found on the leaf samples.

Objective 2 Entomology Results: Montezuma

Yellow aphid complex populations. In the 'Cape Fear' variety, in the month of June, there was no interaction effect between canopy location and treatment (Table 1: June). There was also no significant difference in populations for both canopy location and treatment. In of July, there was no significant difference between yellow aphid complex populations in hedged trees and non-hedged trees (Table 1: July). In August, there was no interaction between canopy location and treatment. Yellow aphid numbers were not statistically different between hedged trees and non-hedged trees, but the lower canopy of the trees had significantly more aphids than the upper canopy (Table 1: August). For 'Stuart' variety in June, there was no interaction between the canopy location and treatment. Yellow aphid numbers were the same on hedged trees and non-hedged trees, however there were less aphids in the upper canopy than the lower canopy (Table 2: June). In July, there was no significant difference between hedged trees and non-hedged trees (Table 2: July). For August, no significant interaction was found between treatment and canopy location. Yellow aphid populations did not differ significantly between hedged trees and non-hedged trees. More aphids were found in the lower canopy than the upper canopy (Table 2: August).

Black pecan aphids. Black pecan aphids were only present in August. For both the 'Cape Fear' and 'Stuart' varieties, there was no significant interaction between the canopy location and treatment.

For ‘Cape Fear’, the lower canopy had more black pecan aphids than the upper canopy, but the number of aphids between the hedged trees and non-hedged trees was similar (Table 3). For ‘Stuart’, the upper canopy had lesser aphids than the lower canopy, and the hedged trees had lower number of aphids than the non-hedged trees (Table 4).

Pecan leaf scorch mite (PLSM). Pecan leaf scorch mites were not present until later in the growing season. In July, for both varieties, there was no difference in PLSM numbers between hedged trees and non-hedged trees. In August, there was no interaction between canopy location and treatment for both varieties. The amount of PLSM did not significantly vary between the canopy location or treatment (Tables 5 and 6).

Leaf miners. No leaf miners were found in June and July for both the ‘Cape Fear’ and ‘Stuart’ varieties. In August, there was no interaction effect between treatment and canopy location in the ‘Cape Fear’ variety, and similar degree of damage was found between canopy locations and treatments (Table 7). For the ‘Stuart’ variety in August, the canopy location and treatment had no interaction. The upper canopy had lesser leaf miner damage than the lower canopy, and but the hedged trees and non-hedged trees had similar amounts of damage (Table 8).

Insect related nut injury before harvest. In June, a total of 682 nuts were sampled. In these nuts, only one had evidence of pecan nutcase bearer infestation. In the month of July, a total of 240 nuts were sampled from the lower canopy, however no damage from either pecan nutcase bearer or shuckworm was found.

Insect injury on harvested nuts. At harvest, a total of 563 nuts were collect between the ‘Cape Fear’ and ‘Stuart cultivars. Of the 563 nuts samples, no shuckworms were found, and only four nuts had any damage. No injuries from nut curculio or stink bugs were found on the harvested samples.

Table 1. Mean number of yellow complex aphid nymphs and adults sampled in 2020 from the upper and lower canopy of 'Cape Fear’ pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total Yellow Complex Aphids per two leaves		
		June	July	August
Hedged	Upper	0.43 ± 0.08	-	0.57 ± 0.27
	Lower	0.53 ± 0.15	0.37 ± 0.13	5.64 ± 1.98*
Non-Hedged	Upper	0.20 ± 0.10	-	0.40 ± 0.17
	Lower	0.63 ± 0.19	0.97 ± 0.32	5.10 ± 1.47*
	Interaction Effects (*P* Value)	0.2206		0.9746
	Non-hedged/Hedged (*P* Value)	0.4171	0.1515	0.7384
	Upper/Lower (*P* Value)	0.1101		0.0017

Columns with * after values had significantly more yellow aphid complex aphids in the lower canopy than the upper canopy. In July, samples were only taken from the lower canopy.

Table 2. Mean number of yellow complex aphid adults and nymphs sampled in 2020 from the upper and lower canopy of ‘Stuart’ pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total Yellow Complex Aphids per two leaves

		June	July	August
Hedged	Upper	0.37 ± 0.14	/	2.60 ± 1.70
	Lower	0.64 ± 0.23*	0.93 ± 0.35	28.75 ± 10.02*
Non-Hedged	Upper	0.11 ± 0.11	/	1.85 ± 0.42
	Lower	0.83 ± 0.34*	0.77 ± 0.15	15.45 ± 6.02*
	Interaction Effects (*P* Value)	0.1195	/	0.3439
	Non-hedged/Hedged (*P* Value)	0.3243	0.6667	0.2819
	Upper/Lower (*P* Value)	0.0167	/	0.0026

Columns with * after values had significantly more yellow aphid complex aphids in the lower canopy than the upper canopy.
In July, samples were only taken from the lower canopy

Table 3. Mean number of black pecan aphids sampled per tree from the upper and lower canopies of 45-year old pecan trees of the 'Cape Fear' variety.

Treatment	Canopy Location	Mean ± SEM No. Black pecan Aphids per two leaves
		August
Hedged	Upper	0.03 ± 0.03
	Lower	0.37 ± 0.03*
Non-Hedged	Upper	0 ± 0
	Lower	0.53 ± 0.43*
	Interaction Effects (*P* Value)	0.4671
	Non-hedged/Hedged (*P* Value)	0.9507
	Upper/Lower (*P* Value)	0.0162

Columns with * after values had significantly more black pecan aphids in the lower canopy than the upper canopy.
In the months of June and July, no black pecan aphids were found in the leaf samples

Table 4. Mean number of black pecan aphids sampled in 2020 from the upper and lower canopy of 45-year-old 'Stuart' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Black pecan aphids per two leaves
		August
Hedged	Upper	0 ± 0
	Lower	0.28 ± 0.14*
Non-Hedged	Upper	0.11 ± 0.11^
	Lower	4.59 ± 2.37*^
	Interaction Effects (*P* Value)	0.0930
	Non-hedged/Hedged (*P* Value)	0.0412
	Upper/Lower (*P* Value)	0.0157

Columns with * after values had significantly more black pecan aphids in the lower canopy than the upper canopy.
Columns with ^ after values had significantly more black pecan aphids in the non-hedged trees than the hedged trees.
In the months of June and July, no black pecan aphids were found in the leaf samples

Table 5. Mean number of total pecan leaf scorch mites in each sample from the upper and lower canopies of 45-year-old hedged and non-hedged 'Cape Fear' pecan trees in 2020.

Treatment	Canopy Location	Mean ± SEM No. total scorch mites per two leaves	
		July	August
Hedged	Upper	/	0.07 ± 0.07
	Lower	1.67 ± 0.84	0.30 ± 0.30
Non-Hedged	Upper	/	0 ± 0
	Lower	0.80 ± 0.21	0.03 ± 0.03
	Interaction Effects (*P* Value)	/	0.8634
	Non-hedged/Hedged (*P* Value)	0.9183	0.3356
	Upper/Lower (*P* Value)	/	0.4582

In July, samples were only taken from the lower canopy.
No pecan leaf scorch mites were found in the samples in the month of June.

Table 6. Mean number of pecan leaf scorch mites sampled in 2020 from the upper and lower canopies of 45-year-old hedged and non-hedged 'Stuart' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. total scorch mites per two leaves	
		July	August
Hedged	Upper	/	2.84 ± 1.11
	Lower	0.76 ± 0.62	7.23 ± 5.33
Non-Hedged	Upper	/	0.20 ± 0.15
	Lower	0.27 ± 0.03	5.85 ± 4.42
	Interaction Effects (*P* Value)	/	0.4864
	Non-hedged/Hedged (*P* Value)	0.4650	0.3315
	Upper/Lower (*P* Value)	/	0.1567

In July, samples were only taken from the lower canopy
No pecan leaf scorch mites were found in the leaf samples in the month of June

Table 7. Mean number of leaf miners sampled in 2020 from the upper and lower canopies of 45-year-old hedged and non-hedged 'Cape Fear' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total Leaf miners per two leaves
		August
Hedged	Upper	0.20 ± 0.16
	Lower	0.49 ± 0.07
Non-Hedged	Upper	0.10 ± 0.10
	Lower	0.50 ± 0.26
	Interaction Effects (*P* Value)	0.7548
	Non-hedged/Hedged (*P* Value)	0.7913
	Upper/Lower (*P* Value)	0.0819

In the months of June and July, no leaf miners were found in the leaf samples.

Table 8. Mean number of leaf miners sampled in 2020 from the upper and lower canopies of 45-year-old hedged and non-hedged 'Stuart' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total Leaf miners per two leaves
		August
Hedged	Upper	0.21 ± 0.11
	Lower	0.56 ± 0.20
Non-Hedged	Upper	0.21 ± 0.11
	Lower	0.59 ± 0.15
	Interaction Effects (*P* Value)	0.8384
	Non-hedged/Hedged (*P* Value)	0.8384
	Upper/Lower (*P* Value)	0.0576

In the months of June and July, no leaf miners were found the in the leaf samples.

Objective 2 Entomology Results: Ray City

Yellow aphid complex. In the 'Creek' cultivar, for all three sample dates, there was no interaction between the canopy location and treatment. There was also no significant difference between treatments and canopy locations in any sample date (Table 1). In the 'Caddo' cultivar, the same results as the 'Creek' cultivar were found for all three sample dates (Table 2).

Black pecan aphids. No black pecan aphids were found in samples collected in June and July for both the 'Creek' and 'Caddo' varieties. For both varieties, there was no interaction between canopy location and treatment on black aphid numbers, and no significant difference between hedged and non-hedged treatments as well as no difference between upper and lower canopy (Table 3).

Leaf miners. In June, leaf miners and the associated damage were only counted in the 'Creek' cultivar. No significant interaction between the canopy location and hedging treatment was observed, and both canopies had similar populations of leaf miners as well as both hedging treatments (Table 4: June). The lower canopies of both the 'Creek' and 'Caddo' cultivars had more scorch mites in July than the upper canopies, however there was no difference between the treatments for either as well as no significant interactions (Table 4: July, Table 5: July). For the 'Creek' cultivar in August, there was no significant interaction between the treatment and canopy location, and similar to July, only canopy location was significantly different with the lower canopy having more (Table 4: August). A significant interaction was observed in August in the 'Caddo' cultivar. The lower canopy of summer hedged trees had the highest numbers of leaf miner damage, while the upper canopies of both the summer hedged and winter hedged trees had the least amount of damage (Table 5: August).

Pecan leaf scorch mites. For both the 'Creek' and 'Caddo' cultivars, no pecan leaf scorch mites (PLSM) were found in June. In July for the 'Creek' cultivar, there was no significant interaction between the treatment and canopy location. The trees hedged in the summer had similar amounts of PLSM as the trees hedged in the winter, but the lower canopies of

the trees had more PLSM than the upper canopy (Table 6: July). For the 'Caddo' cultivar in July, results were similar to the 'Creek' cultivar with no significant interaction between canopy location and treatment, and the only significant difference being between canopy locations (Table 7: July). In August, there was no significant interaction in the 'Creek' cultivar between the canopy location and treatment, and similar to July, the lower canopy had more PLSM than the upper canopy but no significant difference between treatments (Table 6: August). There was significant interaction between the treatment and canopy location in the August samples of the 'Caddo' cultivar. The lower canopy of winter hedged trees had the most PLSM of all the treatment and location combinations while the upper canopies of both summer and winter hedged trees had the least (Table 7: August).

Early season nut injury In June, 990 nuts were sampled, and in July, 980 nuts were sampled. In both months, no pecan nut casebearer or shuckworm injury was recorded.

Harvest. At harvest, 540 nuts were collected. In all the nuts collected, none had any injury related to nut feeding insects.

Table 1. The mean number of yellow aphid complex adults and nymphs in summer and winter hedged trees sampled in 2020 from the upper and lower canopies of 25 year-old 'Creek' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total Yellow Complex Aphids per two leaves		
		June	July	August
Summer	Upper	4.16 ± 2.26	0.30 ± 0.20	0.23 ± 0.19
	Lower	4.03 ± 0.73	0.27 ± 0.09	0.40 ± 0.06
Winter	Upper	2.70 ± 1.26	0.27 ± 0.12	0.30 ± 0.12
	Lower	2.40 ± 1.10	1.07 ±0.38	0.47 ± 0.09
	Interaction Effects (*P* Value)	0.9432	0.1677	1.0000
	Non-hedged/Hedged (*P* Value)	0.2163	0.1670	0.5628
	Upper/Lower (*P* Value)	0.8532	0.1550	0.2201

Table 2. The mean number of yellow aphid complex adults and nymphs in summer and winter hedged trees sampled in 2020 from the upper and lower canopies of 25 year-old 'Caddo' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total Yellow Complex Aphids per two leaves		
		June	July	August
Summer	Upper	3.93 ± 1.64	0.37 ± 0.13	0.37 ± 0.22

	Lower	5.10 ± 0.56	0.47 ± 0.32	0.27 ± 0.15
Winter	Upper	4.90 ± 1.93	0.20 ± 0.20	0.13 ± 0.09
	Lower	2.93 ± 1.13	0.20 ± 0.12	0.27 ± 0.14
	Interaction Effects (*P* Value)	0.0616	0.8321	0.4010
	Non-hedged/Hedged (*P* Value)	0.4133	0.1450	0.4010
	Upper/Lower (*P* Value)	0.5793	0.7144	0.9015

Table 3. The mean number of total adult and nymph black pecan aphids per sample taken in August 2020 from the upper and lower canopies of 25 year-old summer and winter hedged 'Creek' and 'Caddo' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total black pecan aphids per two leaves	
		Creek	Caddo
Summer	Upper	0 ± 0	0 ± 0
	Lower	0.13 ± 0.13	0.47 ± 0.32
Winter	Upper	0.03 ± 0.03	0.03 ± 0.03
	Lower	0.03 ± 0.03	0.07 ± 0.03
	Interaction Effects (*P* Value)	1.0000	0.1571
	Non-hedged/Hedged (*P* Value)	0.4680	0.3867
	Upper/Lower (*P* Value)	0.5787	0.0611

No black pecan aphids were found in samples in the months of June and July

Table 4. The mean number of total leaf miners per sample taken in 2020 from the upper and lower canopies of 25 year-old summer and winter hedged 'Creek' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total leaf miners per two leaves		
		June	July	August
Summer	Upper	0.40 ± 0.21	1.73 ± 1.01	2.23 ± 0.84
	Lower	0.10 ± 0.06	5.63 ± 1.30*	9.03 ± 1.24*
Winter	Upper	0.07 ± 0.03	1.43 ± 0.13	2.46 ± 0.42
	Lower	0.30 ± 0.15	4.57 ± 1.03*	8.30 ± 1.24*
	Interaction Effects (*P* Value)	0.0927	0.5893	0.6345
	Non-hedged/Hedged (*P* Value)	0.8766	0.3488	0.9805
	Upper/Lower (*P* Value)	0.8869	0.0020	0.0010

Columns with * following the means have a significant higher value between canopy locations using a student t-test

Table 5. The mean number of total leaf miners per sample taken in 2020 from the upper and lower canopies of 25 year-old summer and winter hedged 'Caddo' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. Total leaf miners per two leaves	
		July	August
Summer	Upper	2.00 ± 0.17	2.80 ± 0.15 c
	Lower	5.63 ± 0.98*	11.67 ± 0.94 a
Winter	Upper	1.37 ± 0.47	3.23 ± 0.20 c
	Lower	3.77 ± 0.87*	7.50 ± 1.38 b
	Interaction Effects (*P* Value)	0.3880	0.0185
	Non-hedged/Hedged (*P* Value)	0.0798	0.0672
	Upper/Lower (*P* Value)	0.0023	0.0001

Columns with * following the means have a significant higher value between canopy locations using a student t-test
Columns with letters following the means have an interaction between the treatment and canopy location
No leaf miners were found in the samples in the month of June

Table 6. The mean number of total pecan leaf scorch mite adults, nymphs, and eggs per sample taken in 2020 from the upper and lower canopies of 25 year-old summer and winter hedged 'Creek' pecan trees.

Treatment	Canopy Location	Mean ± SEM No. total scorch mites per two leaves	
		July	August
Summer	Upper	0 ± 0	0.23 ± 0.23
	Lower	30.37 ± 26.51*	1.70 ± 1.23*
Winter	Upper	1.50 ± 1.31	0.33 ± 0.24
	Lower	23.73 ± 6.83*	7.57 ± 3.71*
	Interaction Effects (*P* Value)	0.9626	0.2425
	Non-hedged/Hedged (*P* Value)	0.5237	0.1573
	Upper/Lower (*P* Value)	0.0184	0.0366

Columns with * following the means have a significant higher value between canopy locations using a student t-test
No PLSM were found in June

Table 7. The mean number of total pecan leaf scorch mite adults and nymphs per sample taken in 2020 from the upper and lower canopies of 25 year-old summer and winter hedged 'Caddo' pecan trees.

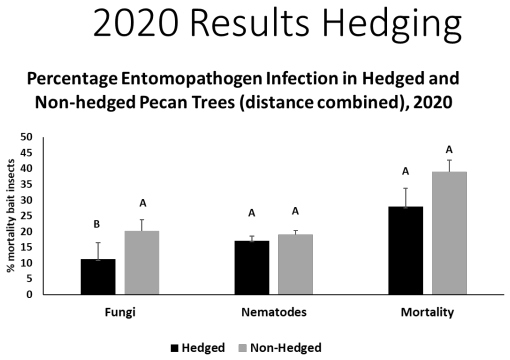
Treatment	Canopy Location	Mean ± SEM No. total scorch mites per two leaves	
		July	August
Summer	Upper	0.96 ± 0.82	0.17 ± 0.17 c
	Lower	140.7 ± 50.64*	3.70 ± 0.25 b
Winter	Upper	0 ± 0	0 ± 0 c
	Lower	87.6 ± 28.59*	11.26 ± 2.89 a
	Interaction Effects (*P* Value)	0.5352	0.0170

Non-hedged/Hedged (*P* Value)	0.2645	0.0600
Upper/Lower (*P* Value)	0.0002	0.0001

Columns with * following the means have a significant higher value between canopy locations using a student t-test
Columns with letters following the means have an interaction between the treatment and canopy location
No PLSM were found in the samples in the month of June

4. Entomopathogen

Results show that the entomopathogenic fungus (*Beauveria bassiana*) was higher in non-hedged plots in Marshallville, where the young trees are planted.



Five sample dates Aug 12 to Sept 9, 2020; % mortality from repeated baiting of *G. mellonella*
Repeated measures analysis; distance from tree*treatment interaction was non-sig

5. Economics (Greg Colson, UGA)

Economics Component - Activities – Year 1

- In collaboration with the project team, a survey instrument was developed and administered to southeastern US pecan growers to obtain estimates and insights on the:
    - Prevalence of hedge-pruning as a management strategy for pecan trees.
    - Perceived (or realized) positive and negative impacts of hedge-pruning on crop production and profitability.
    - Potential barriers and drivers of adoption of hedge-pruning by pecan growers.
    - Research and outreach support that would facilitate pecan growers' assessment of the suitableness of hedge-pruning for their operation.

Economics Component – Brief Summary of Findings – Year 1

- A significant majority of pecan growers perceive positive impacts of hedge-pruning resulting in improved revenues for their operation including:
    - Improved nut quality (93% of growers agree) and nut yield (69% growers agree).
    - Reduced pest pressures and improve spray coverage.
    - Lower risk of wind damage.

- Cost and insufficient evidence of effectiveness and profitability are the most significant barriers to adoption of hedge-pruning by growers.
    - 72% of growers perceive the cost of hedge-pruning to be expensive.
    - Slightly less than half of growers thought the improvement in revenue would outweigh the cost, with 12% of growers stating that hedge-pruning would reduce farm profits.
    - Many growers stated that to evaluate whether to adopt, they need more evidence on (i) the effectiveness of hedge-pruning on operations similar to their own and (ii) the economic returns from the practice.
- The average pecan grower can be characterized as:
    - Interested in potentially adopting hedge-pruning for their operation.
    - Perceiving positive financial revenue impacts from hedge-pruning.
    - Significantly concerned about the cost (equipment and labor) of hedge-pruning.
    - Requiring more information and evidence before adoption.

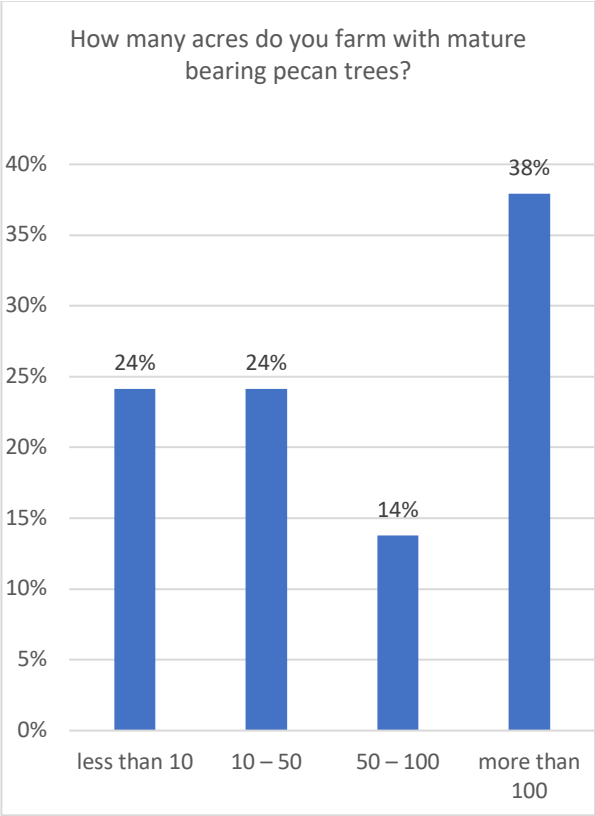
Economics Component - Planned Activities – Year 2

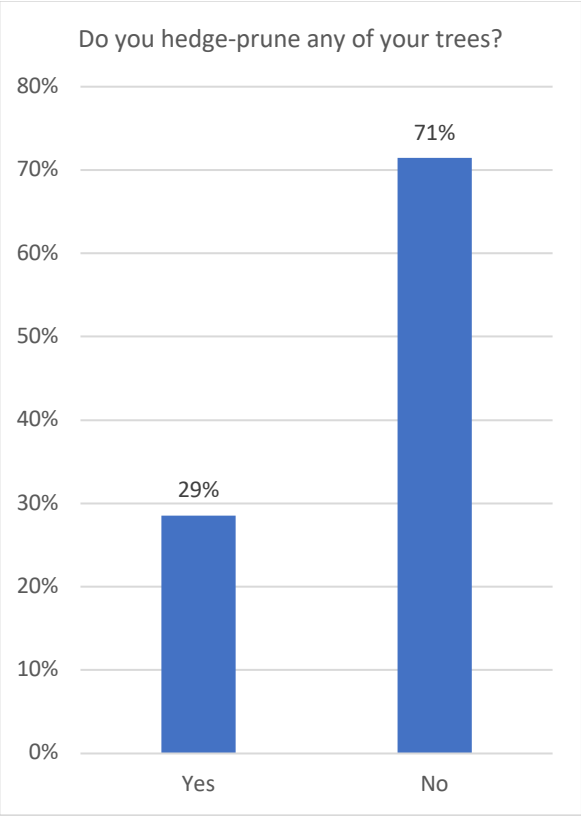
- Create a final report on year 1 survey results incorporating new grower survey responses received during spring and summer 2021.
- Begin collecting and assembling cost, revenue, and production data for the economic assessment of the costs and returns to pecan-hedging.
- Work with project team members as field trial data becomes available to translate findings into a cost-benefit framework.

Pecan grower perceptions of hedge-pruning and barriers and drivers of adoption

Pages 3–8 present brief summaries of responses by pecan growers to key survey questions regarding perceptions of hedge pruning, willingness to adopt, and stakeholder needs to make an informed decision for their operation.

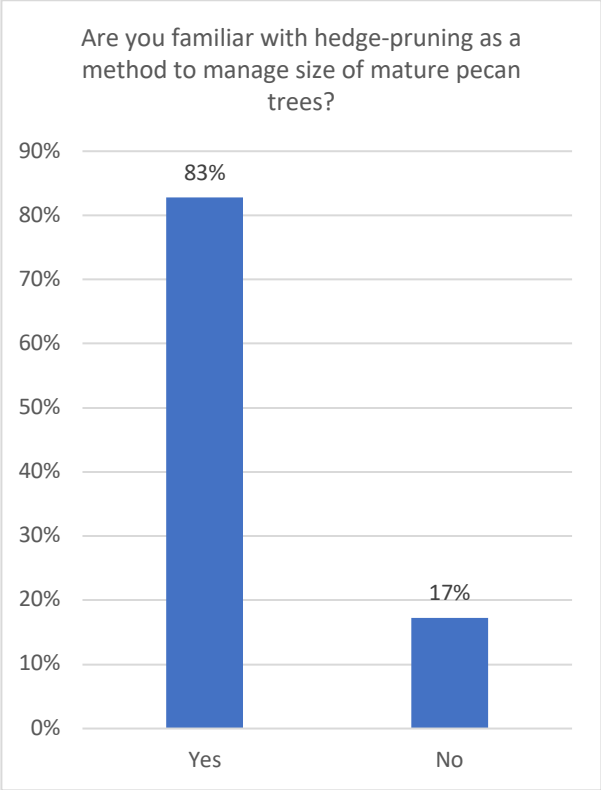
Pecan grower farm size and use of hedge-pruning

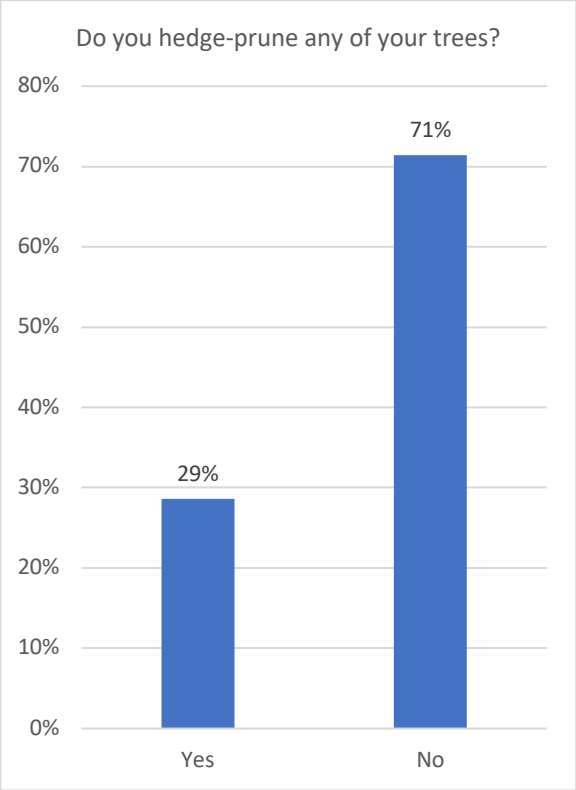




Current adopters of hedge-pruning tend to be larger operations (33% of farms larger than 100 acres hedge-prune compared to 20% of farms less than 100 acres)

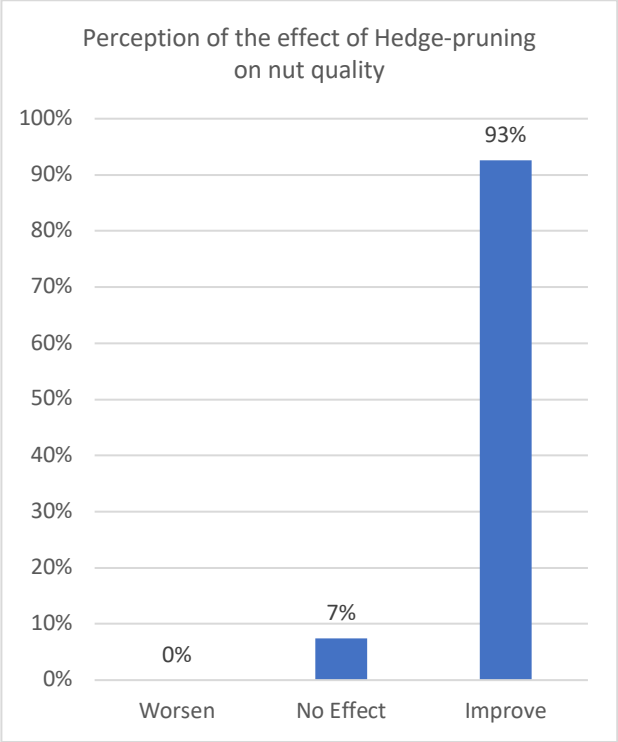
Pecan grower familiarity with hedge-pruning vs. Use of hedge-pruning

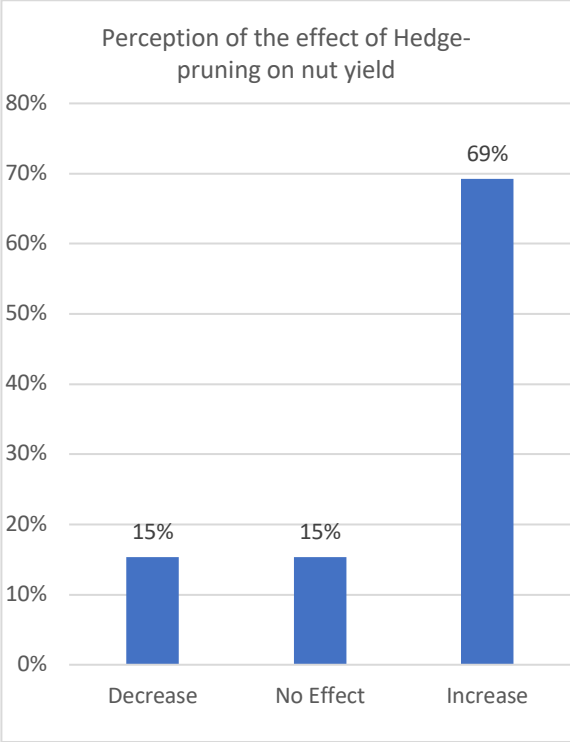




The majority of pecan growers are familiar with hedge-pruning but do not currently hedge-prune for management of mature pecan trees.

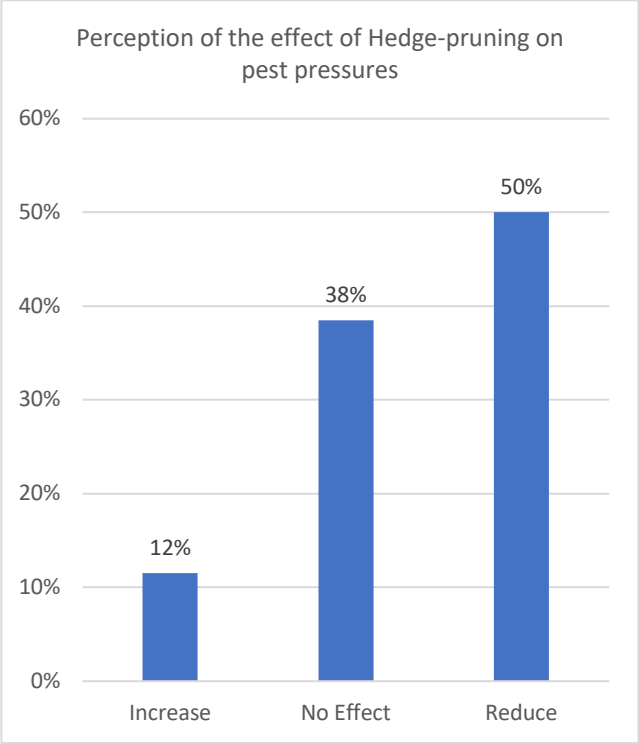
Pecan grower perceptions of the effects of hedge-pruning (part 1 of 2)





The majority of pecan growers perceive a positive impact on nut quality and yield, but the positive impact is stronger for quality.

Pecan grower perceptions of the effects of hedge-pruning (part 2 of 2)



Other perceived benefits stated by growers:

Improved spray coverage

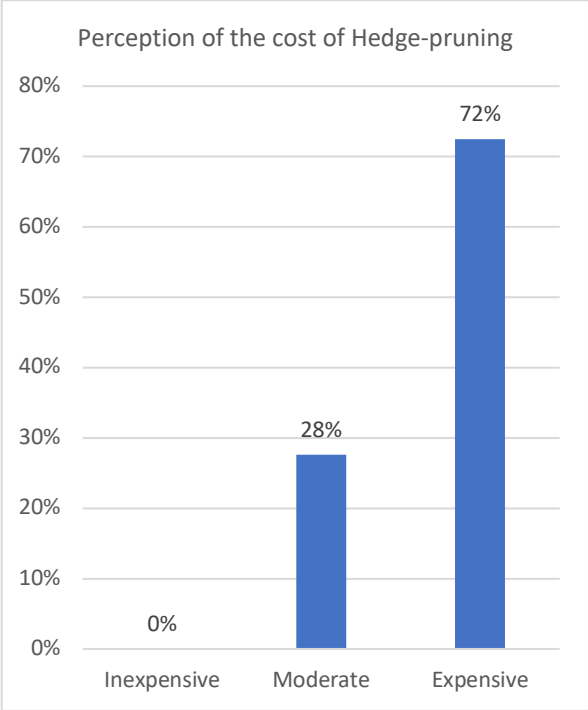
Reducing alternate bearing

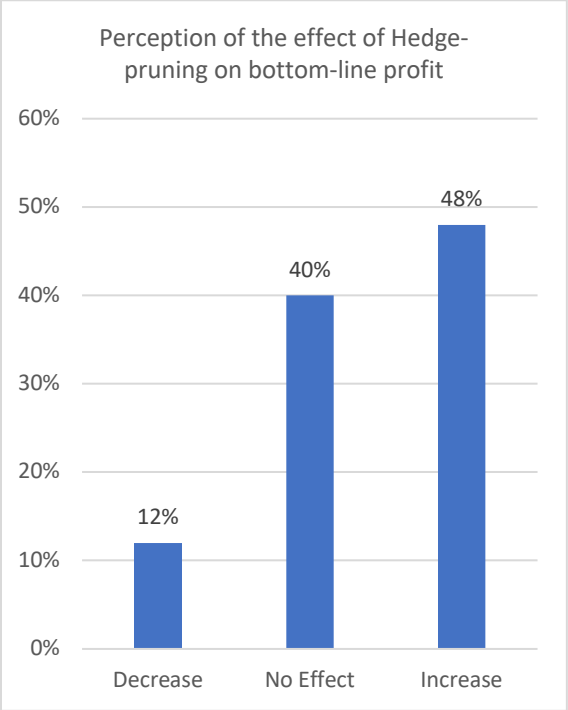
Less wind and storm damage

Better air flow

The majority of pecan growers perceive a reduction of pest pressures from hedge-pruning

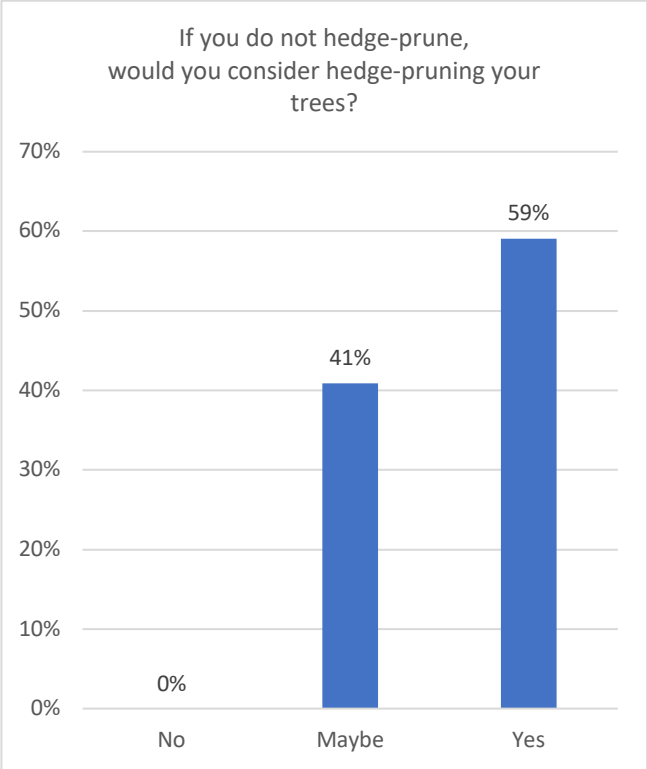
Pecan grower perceptions of the cost and profitability of hedge-pruning





Pecan hedge-pruning is perceived by the majority of growers as expensive. The majority of growers believe that hedge-pruning would not improve or worsen their operations' bottom-lines. However, nearly half of growers perceive the financial benefits would outweigh the cost.

Grower willingness to adopt hedge-pruning and barriers to overcome to facilitate adoption



Key barriers and opportunities identified by growers for adoption of hedge-pruning:

More evidence on the economic and biological benefits of hedge-pruning

Reduction in hedge-pruning costs

Evidence on the economic returns to hedge-pruning

All surveyed growers are open to adopting hedge-pruning in their operation. To assist in the decision whether hedge-pruning is appropriate, growers stated they need to see more evidence from field trials, evidence on the economic returns from the practice, and alleviation of concerns regarding the cost of hedge-pruning.

OUTPUTS:

~10 grower consultations
6 Webinars/talks/presentations
Estimated not less than 50 growers attended the grower meetings where results from this project were presented
Approximately 10 Ag professional attended the said meetings.

2021 Toledo, P., K. Phillips, J. Schmidt and **A.L. Acebes-Doria**. Effects of mechanical hedge-pruning on aphid-parasitoid interactions in southeastern US pecan orchards. ESA Southeastern Branch Meeting. Virtual. March 29-31

2021 Phillips, K., and **A.L. Acebes-Doria.** Impacts of summer and winter hedge-pruning on pest populations in pecans. ESA Southeastern Branch Meeting. Virtual. March 29-31

2021 **Acebes-Doria, A.L**. Updates on pecan integrated pest management. North Carolina Pecan Growers Meeting. Virtual. March 23

2021 **Acebes-Doria, A.L**. Pecan IPM. ESA Eastern Branch Meeting. Virtual. March 24

2020 Phillips, K. and **A.L. Acebes-Doria.** Impacts of hedging on pest populations in pecans. 2020 ESA Annual Meeting, Virtual, Nov. 11-25

2020 **Acebes-Doria, A.L**. Overview of the UGA Entomology Pecan Research and Extension Programs. Georgia Pecan Grower Conference. Tifton, GA, Sept. 10