

# Factors that Affect Fuel Consumption in Logging Systems



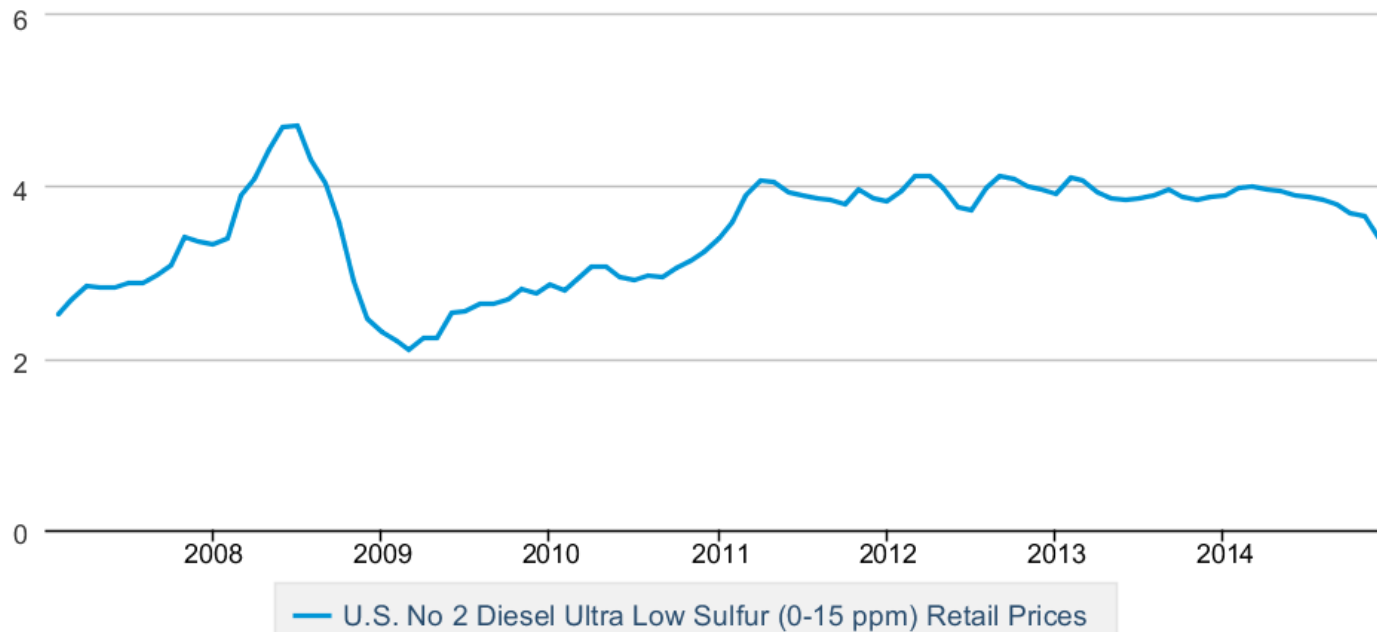
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# National Average Fuel Prices for the Past 8 Years



## U.S. No 2 Diesel Ultra Low Sulfur (0-15 ppm) Retail Prices

Dollars per Gallon



Source: U.S. Energy Information Administration

# Objectives



- Evaluate how many gallons of fuel it takes to produce one ton of wood.
- Evaluate factors that could possibly influence this rate of fuel consumption such as:
  - Average tree size of the harvested tract
  - Type of harvest- (clearcut vs. thinning)
  - Soil moisture of the harvested tract
  - Average slope of the harvested tract

# Methods



- Conduct a literature study, gather fuel data from machine production reports.
  - ✦ Evaluate machine fuel use for each report
  
- Survey loggers to gather more up to date fuel consumption records while noting important harvest characteristics such as:
  - ✦ Machine type, makes, and models
  - ✦ Harvest Type (Clearcut or Thinning)
  - ✦ Slope of the harvested tract
  - ✦ Soil Moisture of the harvested tract
  - ✦ Average tree size of the harvested tract

# Methods- Data Collection



- Fuel consumption will be measured in gallons of fuel used for each ton of wood produced (gal/ton)
- Collect Data from independent logging contractors in two ways:
  - ✦ Weekly Fuel Consumption
  - ✦ Fuel Consumption by Tract

# States Visited



- Alabama
- Florida
- Georgia
- North Carolina
- South Carolina
- Virginia
- Mississippi
- Maine
- Ohio
- Minnesota
- Wisconsin
- Tennessee
- Arkansas
- Louisiana

# Results- Lit Review Data



- Upon evaluation of the machine production reports, it was noticed that a ground based operation consisting of a feller-buncher, grapple skidder, and a loader would average 0.66 gal/ton fuel consumption.

<b>Row Labels</b>	<b>Average Gal/Hr.</b>	<b>Total Sources of Data</b>	<b>Std Dev of Gal/Hr</b>	<b>Average Gal/Cubic Meter</b>	<b>Std. Dev of Gal/Cubic Meter</b>
Delimber	4.57	7	1.15	0.13	0.05
Feller Buncher	6.94	33	2.52	0.29	0.44
Forwarder	2.93	9	0.44	0.16	0.04
Grapple Skidder	6.24	43	6.10	0.27	0.35
Harvester	5.57	20	2.04	0.42	0.20
Loader	6.95	9	0.71	0.10	0.03
Processor	5.96	14	1.09	0.18	0.09

# Results



## Tract Data Total Tons by Crew(s)

Crew	Total Tons Harvested
Crew 1	23,000
Crew 2	700
Crew 3	8,000
Crew 4	6,865
Crews 5-9	9,800
<b>Tract Data Total Tons</b>	<b>48,365</b>

### •Tract Data

#### •9 crews

- Ground-based full tree systems
- 4 crews from Southeast U.S.
- 5 crews from the Lake States

## Weekly Data Total Tons by Crew

Crew	Total Tons
Crew A	119,000
Crew B	91,000
Crew C	111,000
Crew D	19,000
Crew E	94,000
Crew F	52,000
<b>Weekly Data Total Tons</b>	<b>486,000</b>

### •Weekly Data

#### •6 crews

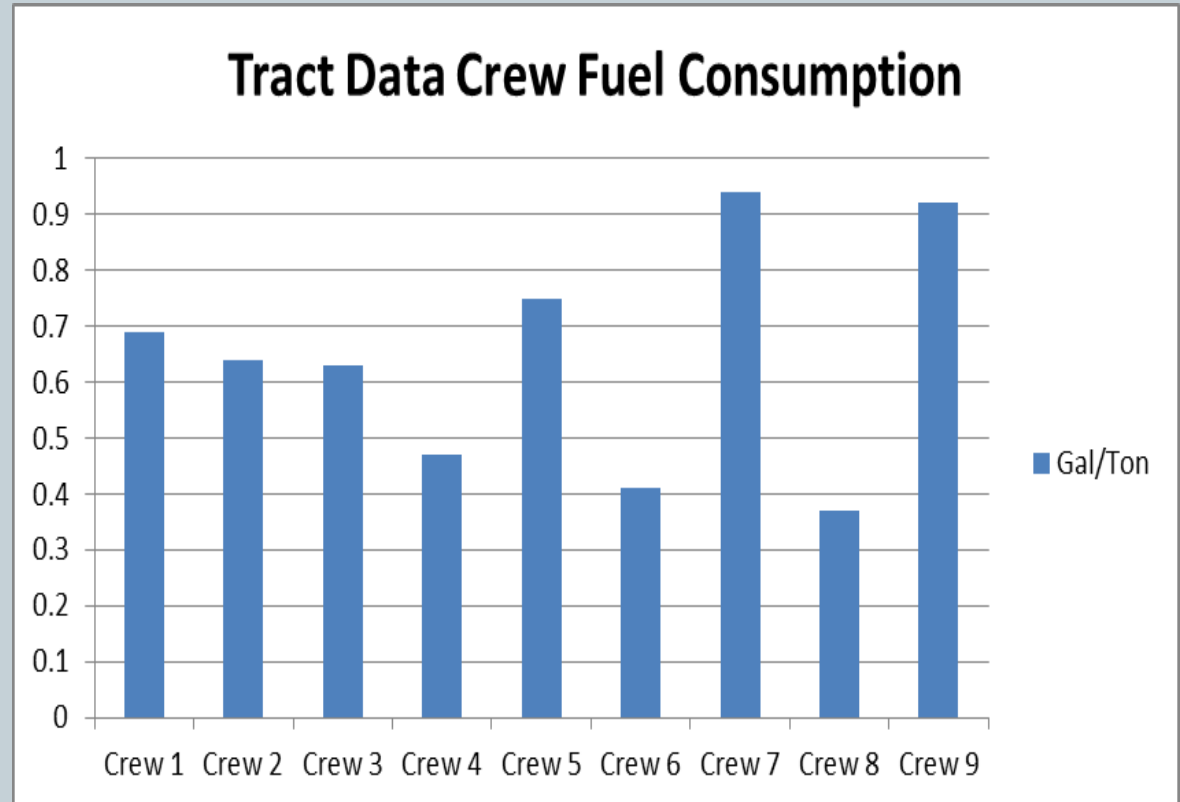
- Ground-based full tree systems
- AL and FLA crews
- High production crews



# Tract Data Average Fuel Consumption



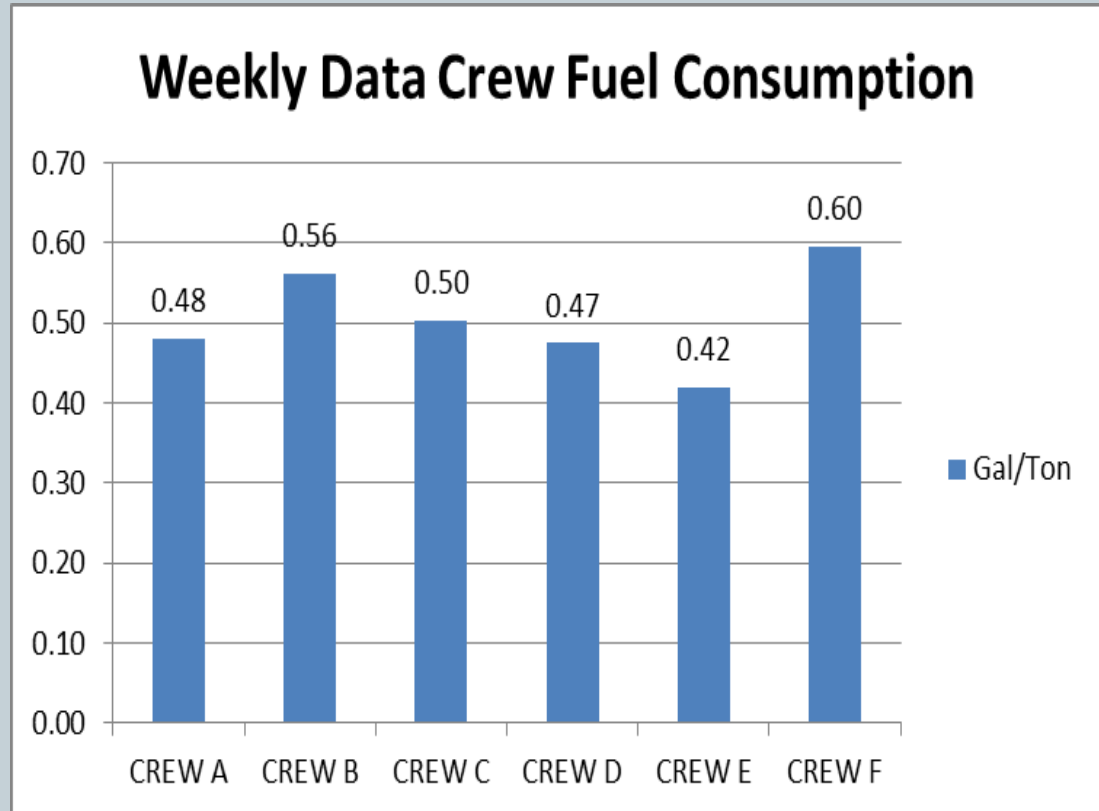
- Some Lake States crews did not report felling data due to chainsaw felling (Crew 6 and Crew 8).
- Due to a presence of little sample size of tracts, tract data was not considered in the statistical analysis



# Weekly Data Average Fuel Consumption



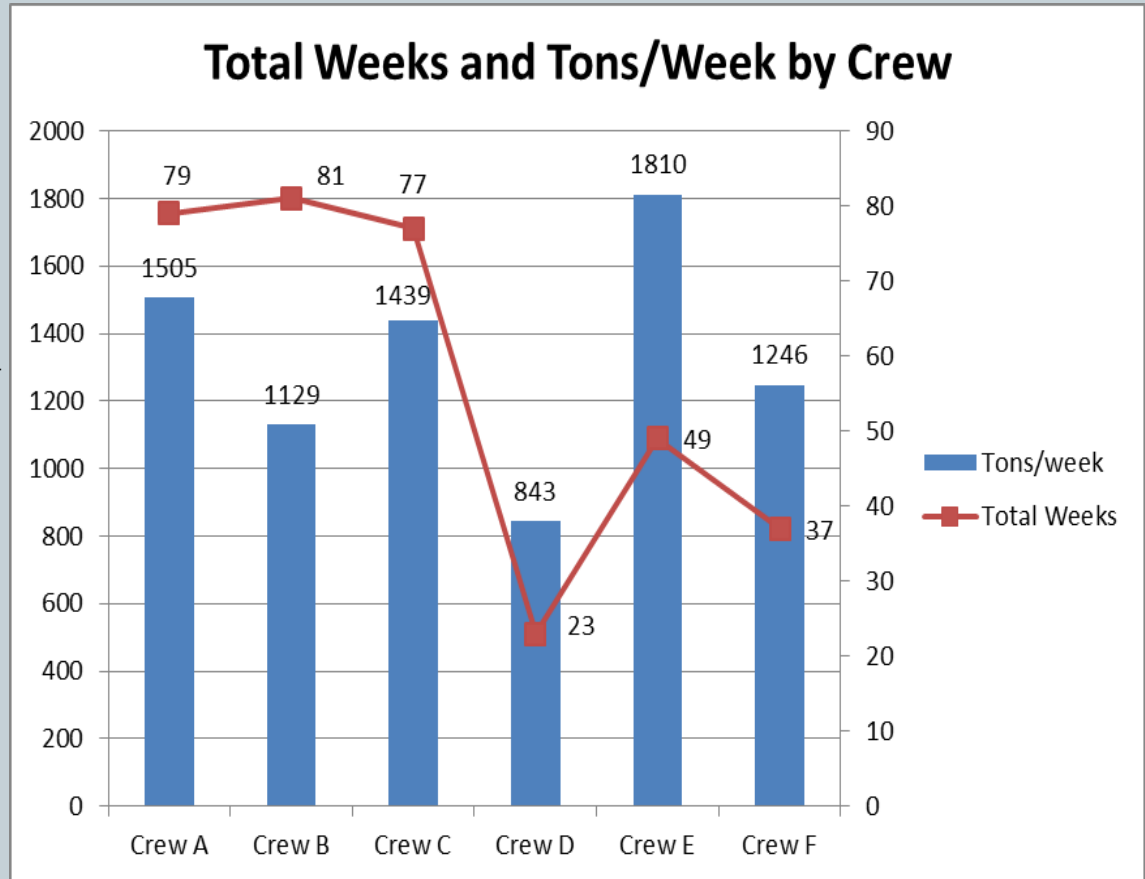
- Weekly Data average fuel consumption was 0.51 gal/ton
- Lowest fuel consumption came from Crew E with 0.42 gal/ton
- Highest fuel consumption was 0.60 gal/ton from Crew F.



# Weekly Production Among Crews



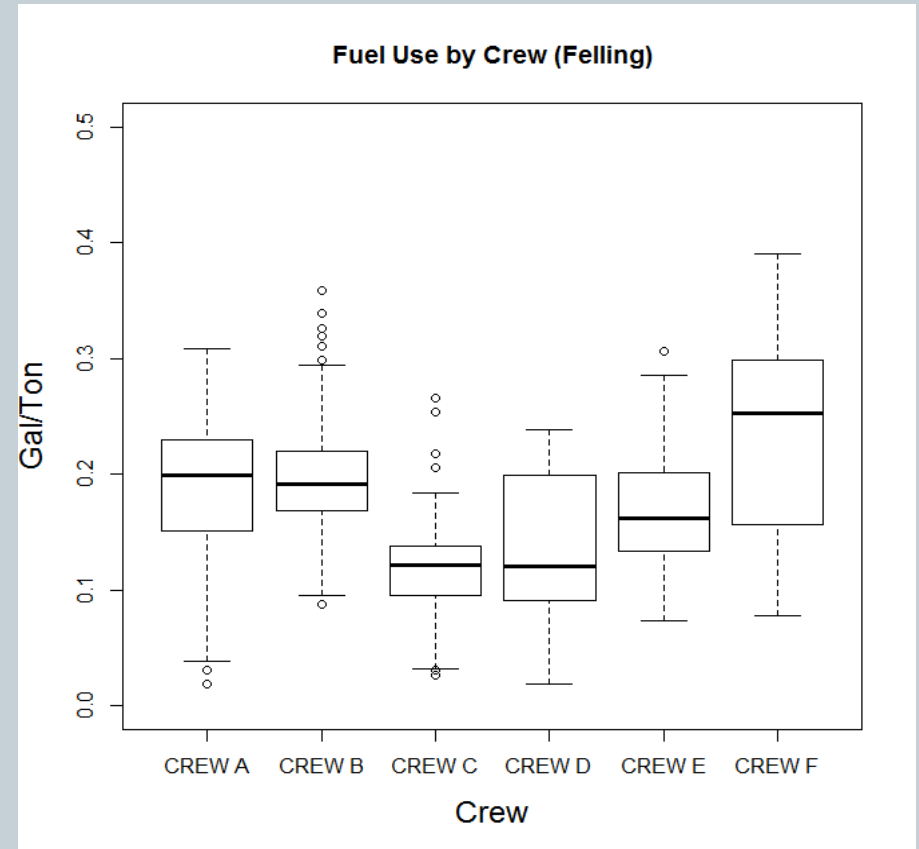
- The most productive crew was Crew E which averaged 1810 tons/week.
- The least productive crew was Crew D which averaged 843 tons/week.
- Crew B submitted the most weeks (81).
- Crew D submitted the least amount of weeks (23)



# Weekly Average Fuel Use- Felling



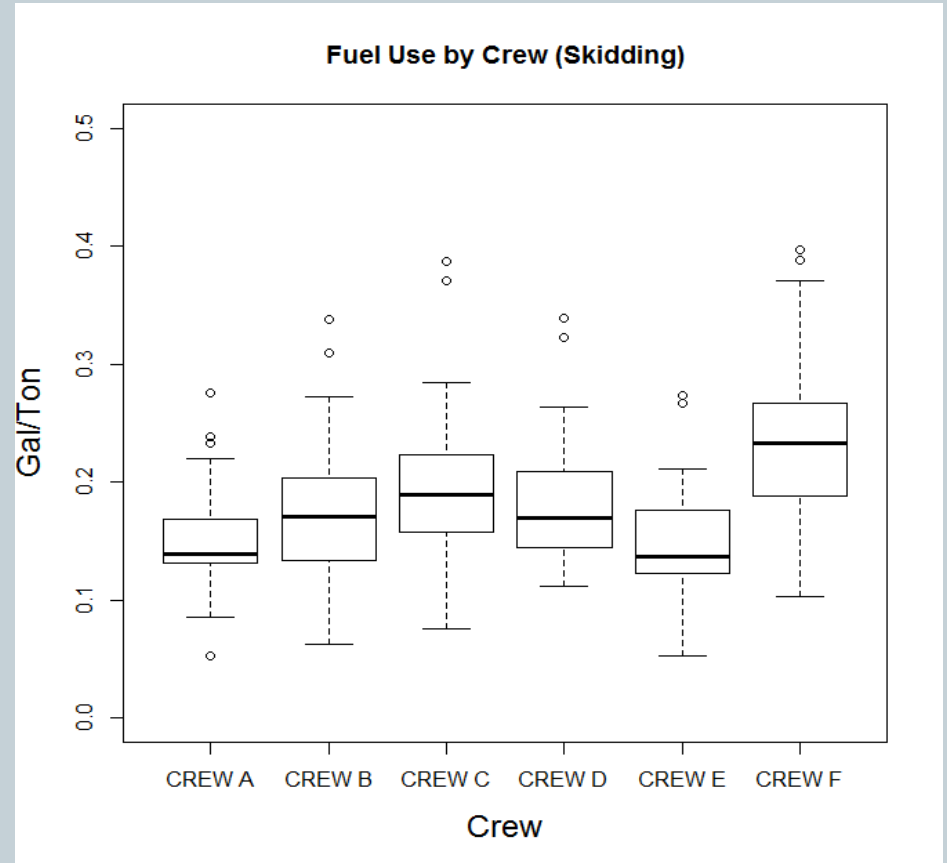
- Felling Analysis ranged from 0.13 gal/ton (Crew C) to 0.24 gal/ton (Crew F).
- The overall average fuel consumption for the felling class was 0.17 gal/ton.



# Weekly Average Fuel Use- Skidding



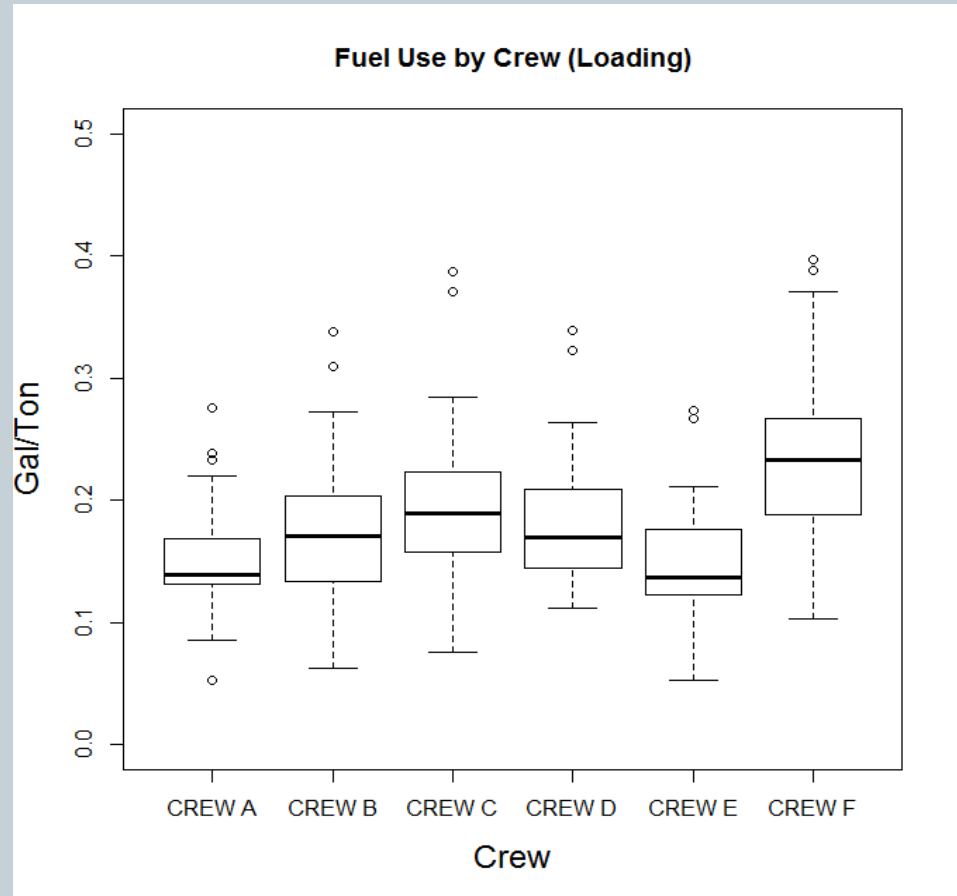
- The lowest skidding fuel consumption was 0.15 gal/ton by Crew A.
- The highest skidding fuel consumption was by Crew F with 0.24 gal/ton.
- Average skidding fuel use was 0.18 gal/ton.



# Weekly Average Fuel Consumption- Loading



- The lowest loading fuel consumption was from Crew E with 0.07 gal/ton.
- The highest loading fuel consumption was from Crew B with 0.15 gal/ton.
- The average loading fuel consumption was 0.11 gal/ton.



# Evaluating Factors that could Affect Fuel Consumption

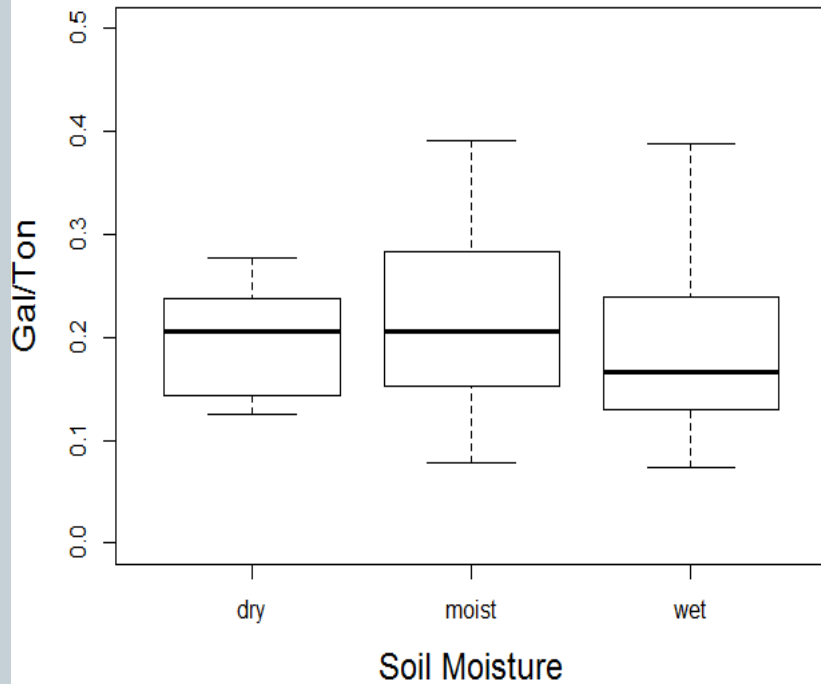


- Soil Moisture, Slope, Average tree size, Harvest Type
- Soil Moisture and Slope evaluated for felling and skidding classes (Loading excluded from evaluation).
- Average tree size in diameter converted to Average Merchantability Class (pulpwood=6" & 7" DBH, chip-n-saw=8"-11" DBH, sawtimber= 12"-up DBH).
- Harvest Type evaluated for each machine and total logging system.

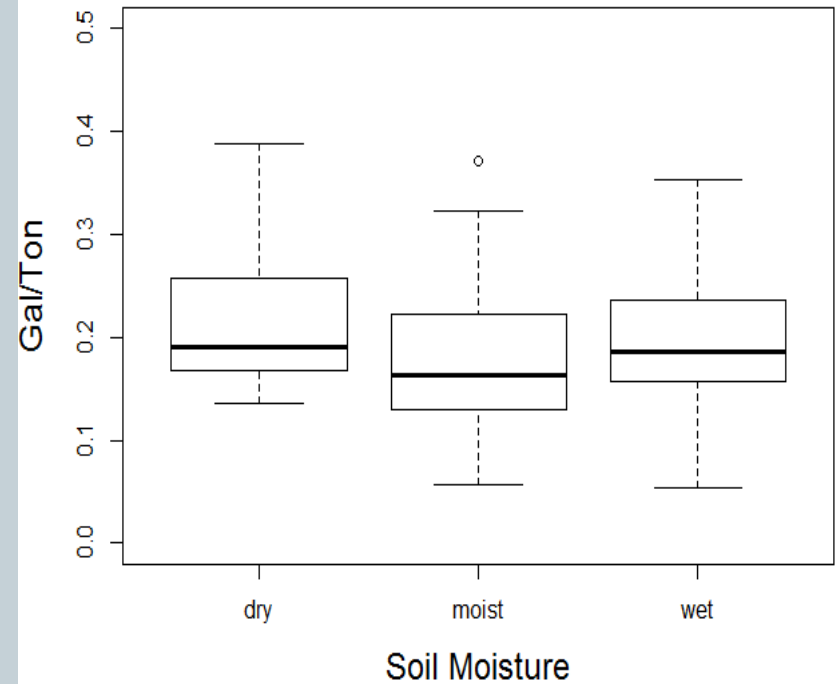
# Soil Moisture Effect



### Felling Fuel Use by Soil Moisture



### Skidding Fuel Use by Soil Moisture

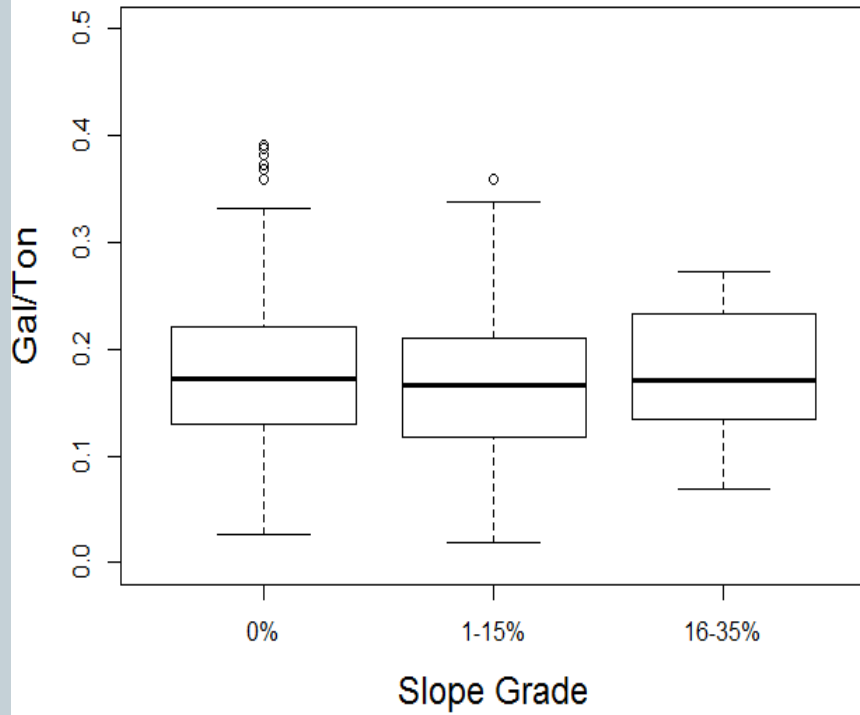




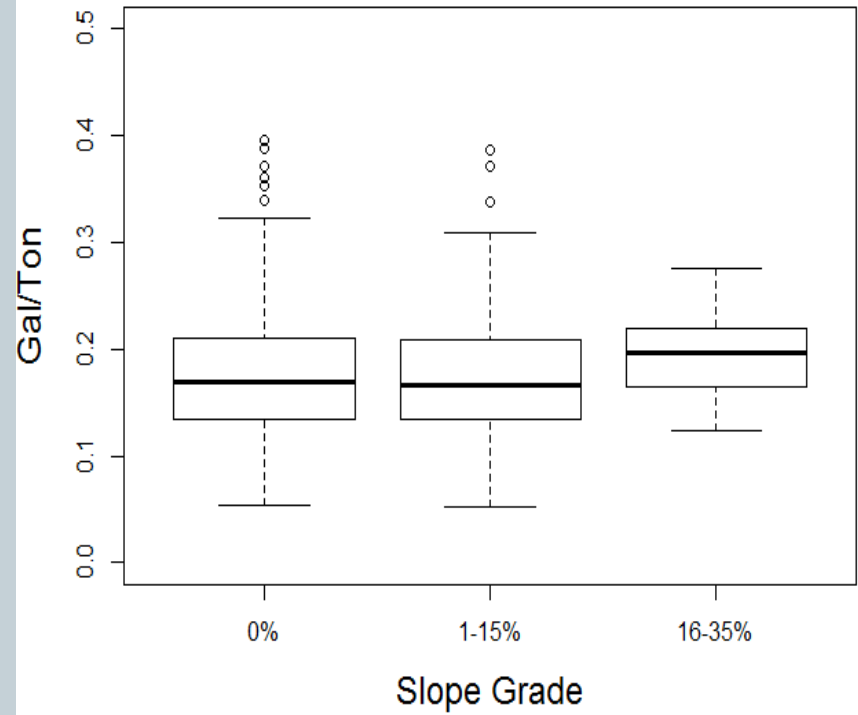
# Slope Effect



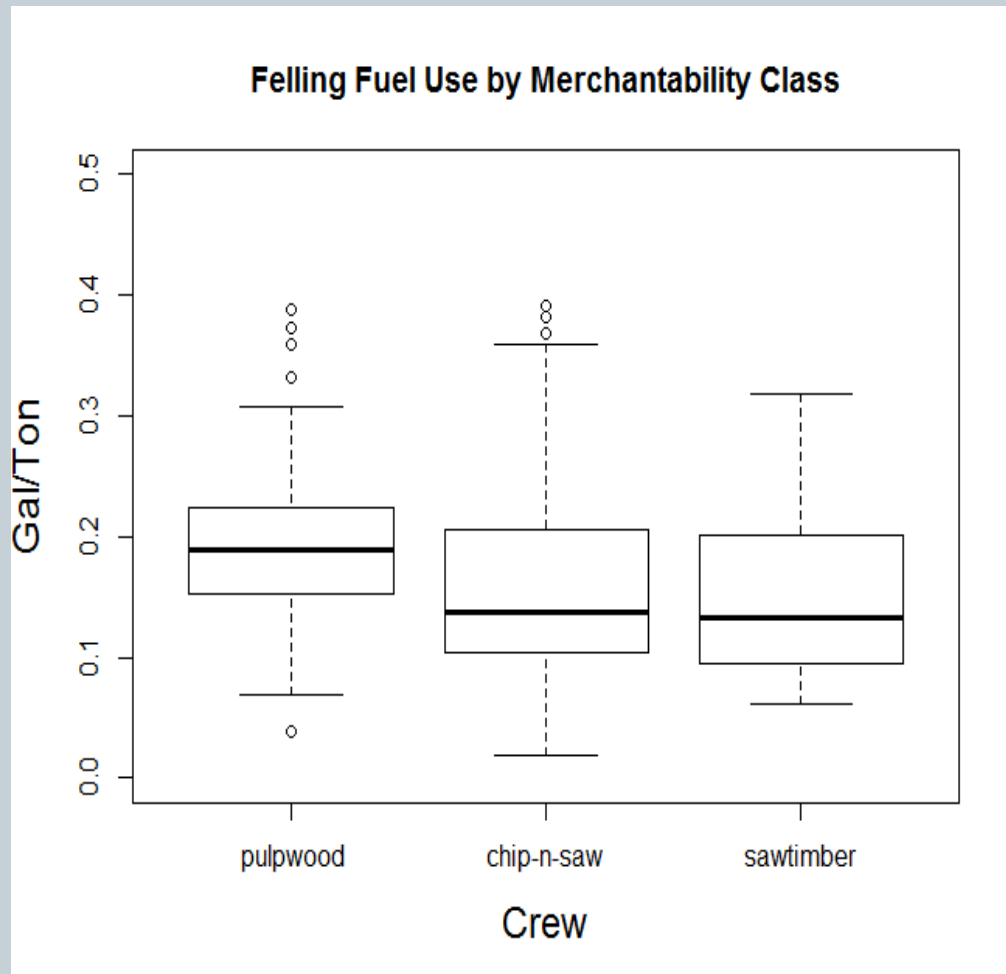
**Fuel Use by Slope (Felling)**



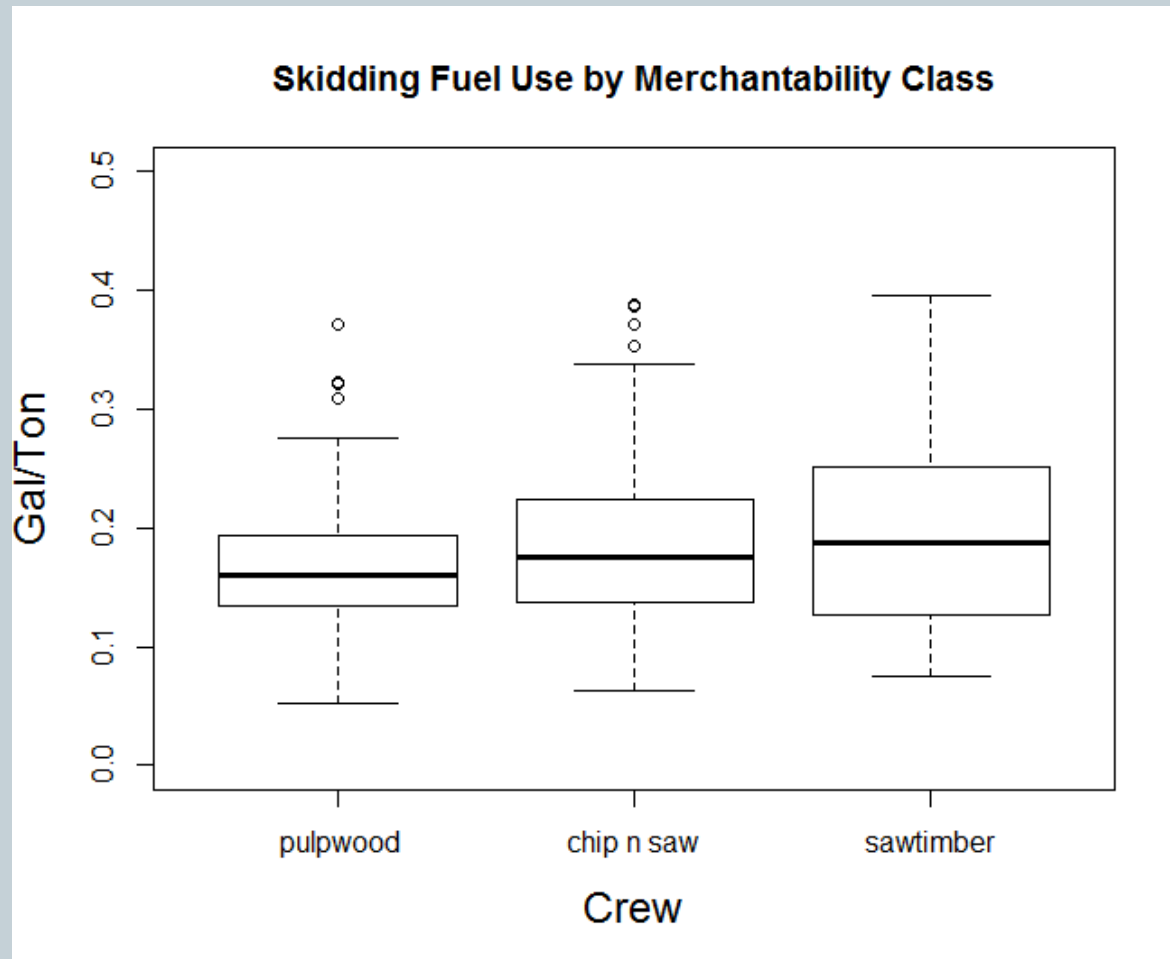
**Fuel Use by Slope (Skidding)**



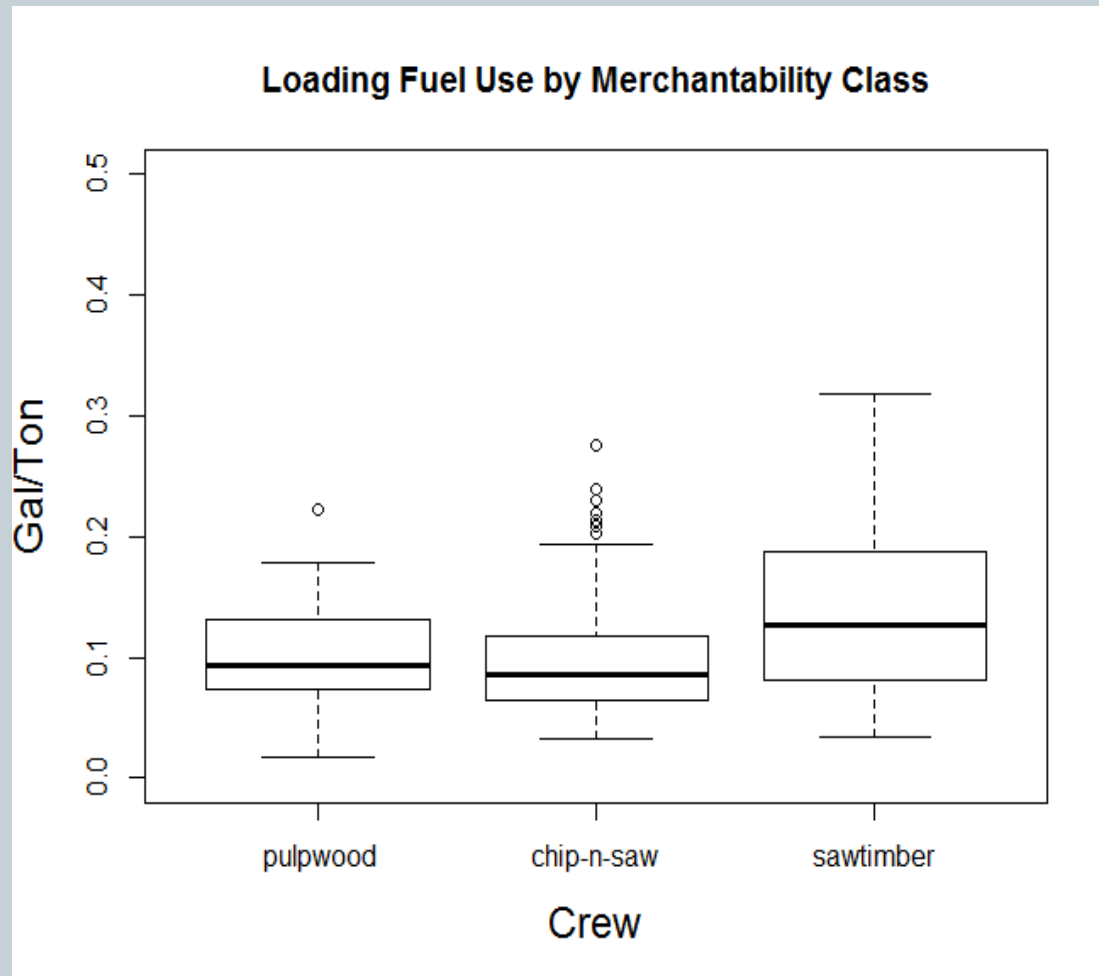
# Average Merchantability Class- Felling



# Average Merchantability Class- Skidding



# Average Merchantability Class

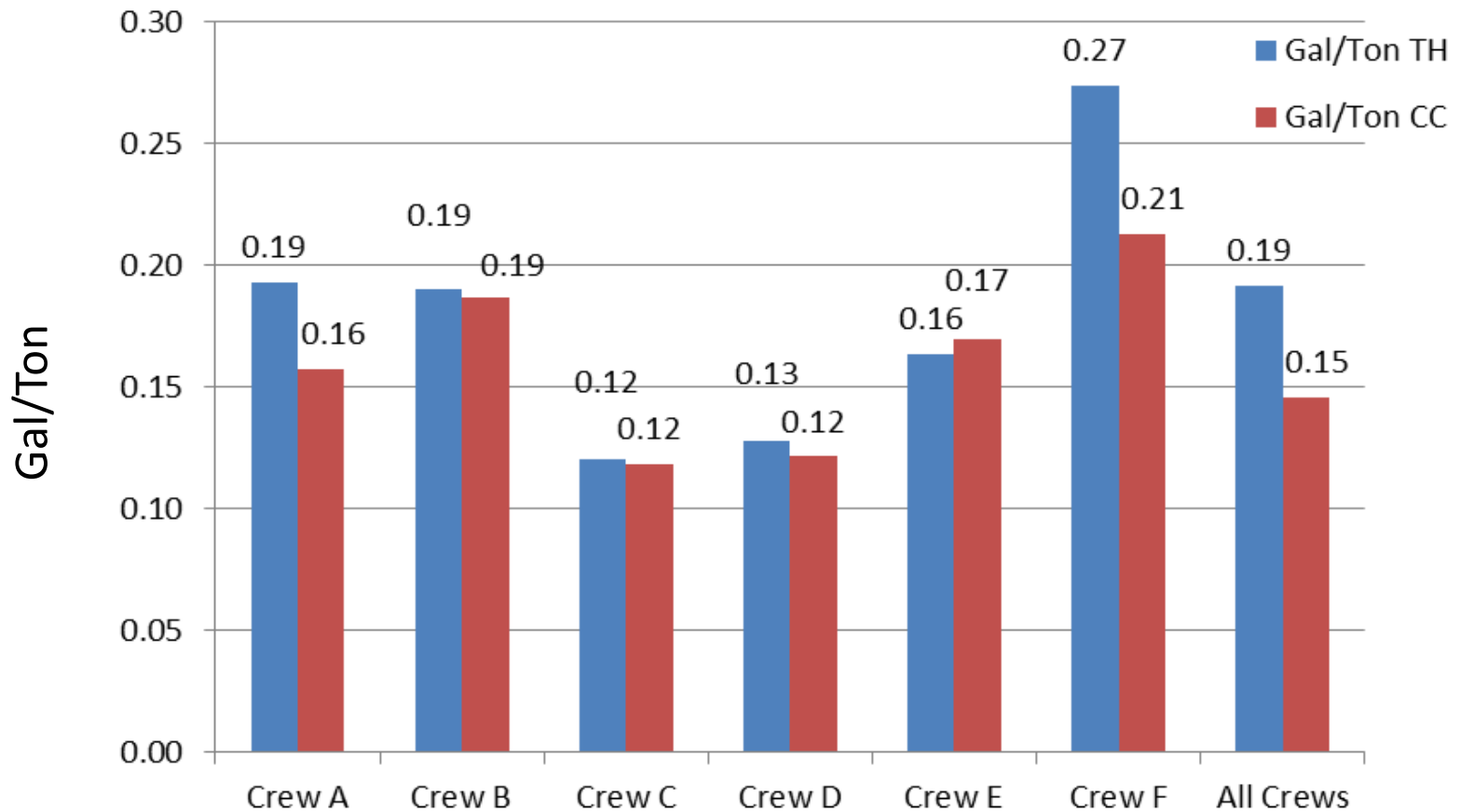


# Harvest Type Effect

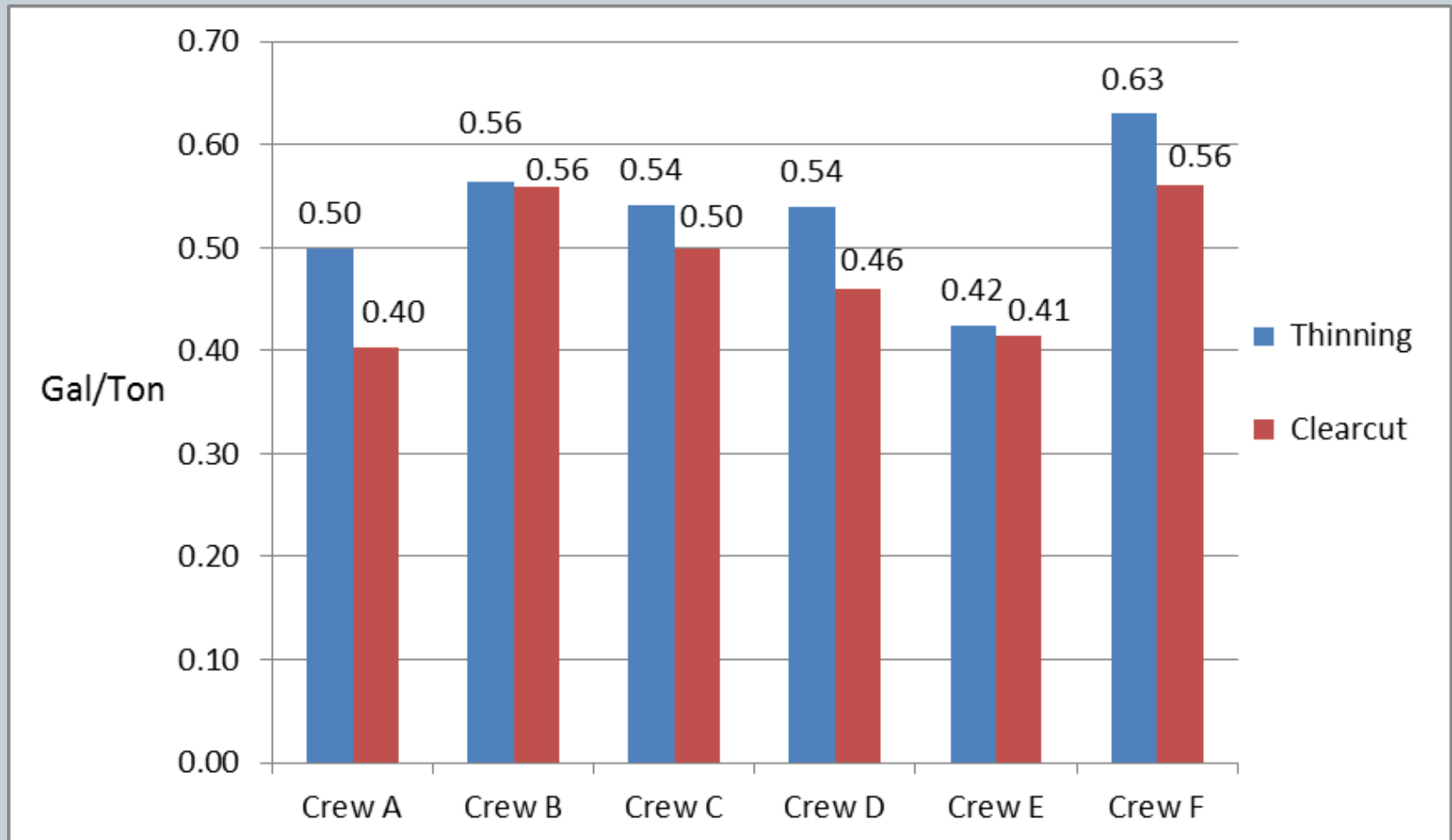


Crew	% Tons TH	% Tons CC	Total Tons	Total Weeks TH	Total Weeks CC	Total tons TH	Total Tons CC
Crew A	78%	22%	118,920	63	16	92,370	26,550
Crew B	78%	22%	91,465	63	18	71,524	19,941
Crew C	5%	95%	110,800	6	71	5,784	105,016
Crew D	18%	82%	19,399	5	18	3,567	15,832
Crew E	59%	41%	88,693	29	20	52,571	36,122
Crew F	57%	43%	46,114	21	16	26,314	19,800
All Crews	53%	47%	475,391			252,130	223,261

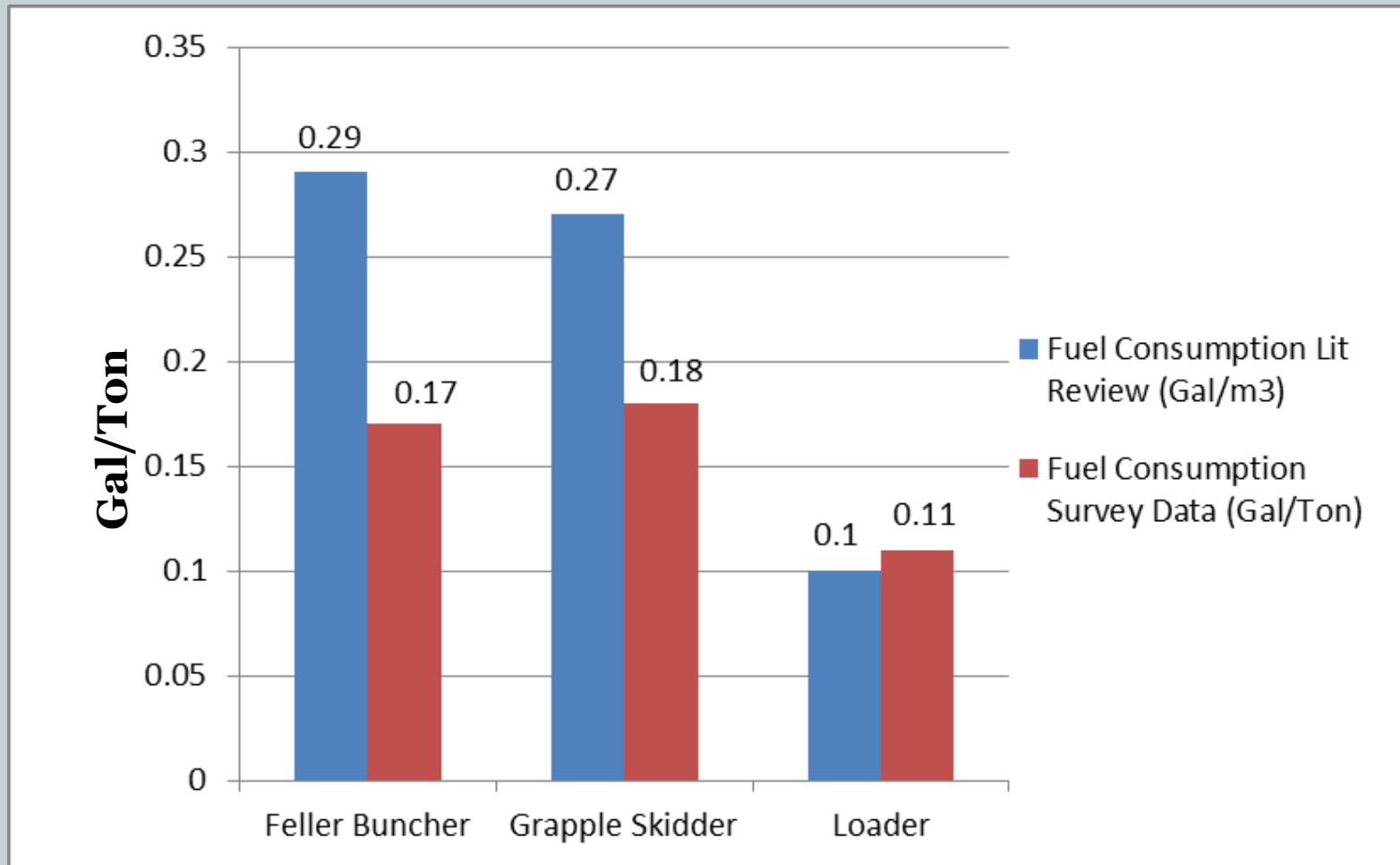
# Harvest Type Effect-Felling



# Harvest Type Effect- Crew Fuel Use Comparison

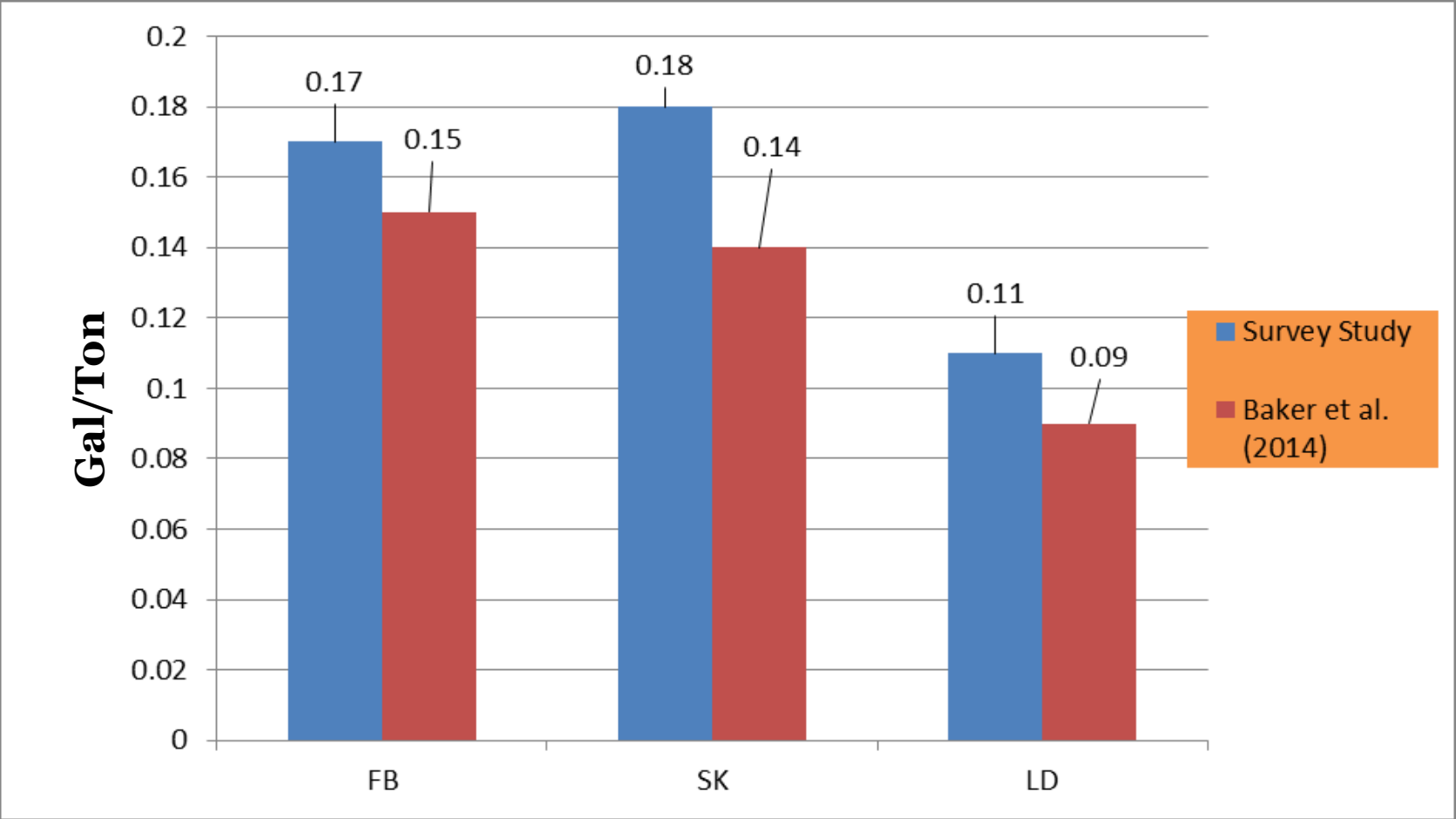


# Comparing Lit Review and Survey Findings





# Comparing a Similar Study



# Conclusions- System and Machine Fuel Use



- Full tree ground based logging operations average 0.51 gal/ton fuel consumption
- Felling machines average 0.17 gal/ton fuel consumption
- Skidding machines average 0.18 gal/ton fuel consumption
- Loading machines average 0.11 gal/ton fuel consumption.

# Conclusions



- Evaluation of soil moisture and slope did not result in a statistically significant effect on fuel consumption
- Crew differences contributed to a great deal of variability in fuel consumption.
- Evaluation of harvest type effect on fuel consumption showed that thinnings use more fuel than clearcuts in the felling class as well as the overall logging system.

# Conclusions



- Average merchantability class of harvested trees had a statistically significant effect on fuel consumption in all three harvesting classes.
- Felling pulpwood uses more fuel than felling chip-n-saw wood
- Skidding sawtimber uses more fuel than skidding pulpwood
- Loading sawtimber uses more fuel than loading chip-n-saw wood and pulpwood

# Acknowledgements



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Wood Supply Research Institute



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# Questions?

