Evaluation of two baling systems for harvesting biomass on the Osceola National Forest, Florida, United States

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1. Introduction

This study was developed in the Osceola National Forest (near Lake City), Florida

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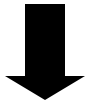
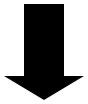
To achieve the DISERED CONDITION on pine flatwoods,
(open stand with a low shrub layer and a rich herbaceous ground cover)
managers have implemented: thinning, prescribed burning, longleaf restoration…



However, the prescribed fire yearly target (30,000 acres) on the ONF has not been reached due to unfavorable weather conditions in concert with heavy fuel loading from a lack of historic burning and smoke management (I-10 bisects the forest).

1. Introduction

So, the removal of the excessive fuel loading would reduce the risk of catastrophic wildfire, facilitate the reintroduction of prescribed fire across a larger landscape and improve wildlife habitat.



Besides the **FIRE FUEL REDUCTION** and the **FOREST HEALTH IMPROVEMENT**, benefits of harvesting biomass may include

ENERGY PRODUCTION

2. Materials & Methods

2.1. Area

3 different sites – stands with slash and longleaf pine

Prior to the machine evaluation, an understory survey was done on each site to determine biomass levels per area and species composition

2. Materials & Methods

Pre-treatment biomass levels in green tons per acre for the three study sites.

Site	Shrubs[1]	Pine		Maple[2]	Wax myrtle[3]	Total
		Dbh < 1-inch	1 ≤ Dbh ≤ 5.5			
1	7.24	0.0	0.14	0.0	0.0	7.38
2	7.42	0.0	0.78	0.10	0.02	8.32
3 – Block 1	5.66	4.03	28.92	0.0	0.30	38.91
3 – Block 2	10.29	2.07	9.98	0.0	0.61	22.95

[1] Includes palmetto, gall berry, bay and wax myrtle with Dbh < 1-inch.
[2] Sizes ranged from 1.1 to 2.1 inches Dbh.
[3] Stems with 1-inch Dbh and larger.

2. Materials & Methods

98%

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Site 1

17.5 trees/acre

12.2 ft^2/acre

2. Materials & Methods

89%

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Site 2

85 trees/acre

59.1 ft^2/acre

2. Materials & Methods

15% 10% 74%

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Site 3 – Block 1

Shelterwood stand with 9.7 trees/acre of slash pine overstory and a very dense midstory

2. Materials & Methods

45%

43%

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Site 3 – Block 2

Shelterwood stand with 9.7 trees/acre of slash pine overstory and a very dense midstory

2. Materials & Methods

2.2. Systems

Bio-baler & Cat Challenger MT565B tractor

- Bio-baler (cutter-shredder-baler prototype)

  Developed by Agriculture and Agri-Food Canada & Université Laval, QC
  Commercial round baler (New Holland BR740) as the harvest platform
  20 flail hammers combining cutting and shredding functions

- 145-hp Caterpillar Challenger MT565B tractor

2. Materials & Methods

2.2. Systems

Claas baler & Cat Challenger MT545B tractor + Supertrak mulcher

1st operation

cutting and shredding

- 140-hp Supertrak tractor (SK 140 TR) &
  Fecon head (BH-74 SS) 30 chipper teeth
- 300-hp Supertrak tractor (SK 300 TR) &
  Fecon head (BH-120) 48 carbide teeth

2. Materials & Methods

2.2. Systems

Claas baler & Cat Challenger MT545B tractor + Supertrak mulcher

2nd operation

baling

- Claas Rollant 250
- 120-hp Caterpillar Challenger MT545B tractor

2. Materials & Methods

2.3. Data collection

- Time study
  - machines were timed
  - activity recorders were used to collect some data
- Distances and areas
  - distance measuring wheel
  - GPS
- Bale measurements
  - dimensions were measured with a tape
  - weights were measured with a hanging dial scale

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- Fuel consumption - using a metered refueling tank
- Cost estimates - machine rate approach described by Miyata (1980)

3. Results

3.1. System performance

Site 1 and Site 2

	Bio-baler & MT565B		Claas baler & MT545B	
Site	1	2	1	2
Time per bale (min)	15.30	13.50	6.20	6.84
Bales per hour	3.92	4.44	9.68	8.78
Acres/h	1.03	0.73	1.77	1.27
Green tons per productive hour	2.22	2.62	6.69	5.52
Green tons per acre	2.15	3.59	3.77	4.35
Fraction of understory harvested	0.29	0.43	0.51	0.52

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3.1. System performance

Site 1 and Site 2

	SK 140		SK 300	
Site	1	2	1	2
Acres/h	0.74	1.08	*	0.89

* SK 300 mulcher was not evaluated on Site 1.

3. Results

3.1. System performance

Site 3 – Block 2

	Claas baler & MT545B *	
No. of passes (SK 140)	1	2
Time per bale (min)	25.8	11.4
Bales per hour	2.3	5.3
Acres/h	0.37	0.79
Green tons per productive hour	1.61	4.19
Green tons per acre	4.32	5.31
Fraction of understory harvested	0.19	0.23

* The Bio-baler did not attempt to work on Site 3.

3. Results

3.1. System performance

Site 3

	SK 140 on Block 2		SK 300 on Block 1	
No. of passes	1	2	1	2
Acres/h	0.69	0.41	0.82	*

* SK 300 mulcher was not evaluated making two passes.

3. Results

3.2. Fuel consumption

Site 1 and Site 2

	SK 140	SK 300	Bio-baler & MT565B	Claas baler & MT545B
Rate per operation (gal/h)	3.89	5.39	3.62	3.94
Specific rate (gal/hp-h)	0.0278	0.0180	0.0250	0.0328
Fuel per unit harvest (gal/t)	1.06	1.51	1.50	0.64
Mulcher & Claas baler (gal/t)	1.71	2.15		

3. Results

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3. Results

3.3. Bale measurements

	Bio-baler			Claas baler		
Site	1	2	3	1	2	3
Size (ft^3)*	61.5	58.9	-	57.6	54.1	52.8
Weight (green lb)*	1130.9	1180.4	-	1383.2	1258.5	1499.5
Density (green lb/ ft^3)*	18.4	20.0	-	24.0	23.3	28.4

* Average.

3. Results

3.4. Costs and benefits

Costs* and benefits (biomass harvested, percentage of understory recovered) from mechanical harvesting.

System	Site 1			Site 2			Site 3		
	Cost ($/ac)	H[1] (t/ac)	R[2] (%)	Cost ($/ac)	H[1] (t/ac)	R[2] (%)	Cost ($/ac)	H[1] (t/ac)	R[2] (%)
Bio-baler	93.10	2.15	29.1	131.88	3.59	43.1	-	-	-
SK 140 (1 pass) & Claas baler	169.92	3.77	51.1	148.44	4.35	52.3	339.38	4.32	18.8
SK 140 (2 passes) & Claas baler	-	-	-	-	-	-	322.47	5.31	23.2

*Costs for mulcher-baler system assume independent operation of the mulcher and the baler. Otherwise, costs of 169.92, 148.44, 339.38 and 322.47 could be as high as 233.86, 159.66, 453.95 and 414.72 ($/ac), respectively. [1] Harvest. [2] Recovery.

3. Results

3.4. Costs and benefits

System costs per unit by site.

System	Site 1		Site 2		Site 3	
	$/bale	$/ton	$/bale	$/ton	$/bale	$/ton
Bio-baler	24.43	43.30	21.66	36.74	-	-
SK 140 (1 pass) & Claas baler	31.18	45.07	21.48	34.12	54.30	78.56
SK 140 (2 passes) & Claas baler	-	-	-	-	51.60	74.65
SK 300 (1 pass) & Claas baler	-	-	34.87	55.39	59.84	75.17

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SK 140 (2 passes) & Claas baler	-	-	-	-	51.60	74.65
SK 300 (1 pass) & Claas baler	-	-	34.87	55.39	59.84	75.17

4. Conclusion

Bio-baler system

has the advantage of performing the cutting, shredding and baling with one machine;

has lower purchase price and fuel consumption rate and → lower cost per acre;

was less productive and encountered limitations to work on the densest site;

recovered lower amount of biomass per area.

Mulcher – Claas baler system

has higher purchase price and fuel consumption rate → higher cost per acre.

Assuming this system would operate very efficiently (no idling time of the faster unit operation which would work at other chores when the other unit operation lagged), cost per ton would likely be slightly higher.

Thank you!