Off-Road Transport of Pinyon/Juniper

by

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Outline

- Background
- Study site and operation
- Study methods
- Results
- Costs
- Conclusions

Background

- Over the last 150 years PJ woodlands have expanded tenfold and occupy 60M acres (Miller and Tuasch, 2001)
- Increase in density per acre and expansion of range of species
- Typical treatments for restoring ecological values – burning, lop-and-scatter, and firewood utilization

Potential Biomass Resource

- PJ accounts for about 1/3 of available woody biomass (7.5 to 11.5M dry tons per year) in the western US (Skog et al. 2008)

- More than any other single woody feedstock in the region

Barriers to Realizing Potential Utilization

1) Reducing cost of harvest and processing

2) Finding conversion processes that are compatible with properties of this material

Historical Data

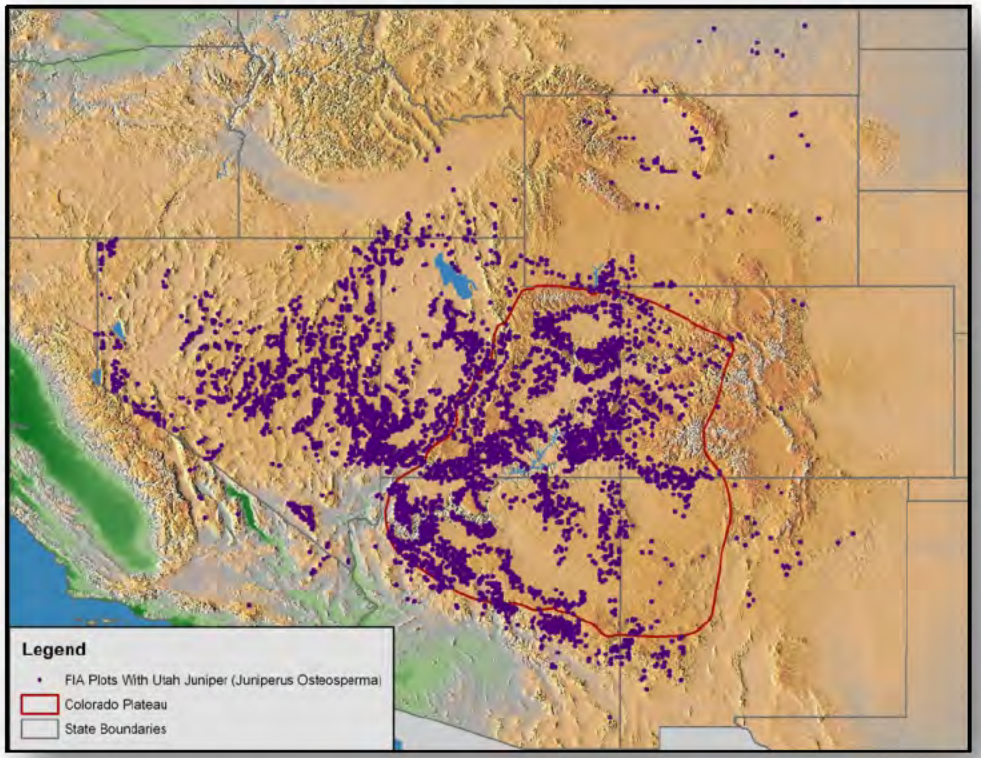
1) Felling, skidding, and chipping PJ - $70/dry ton (Western Governor's Association Report)

2) Grapple skidder and front-end loader – 6 green tons/hr at $7/green ton (Baughman, 2004)

3) Grapple skidders working in western juniper in Oregon - 3.8 to 4.9 green tons/hr at $11.50/ton (The Yankee Group)

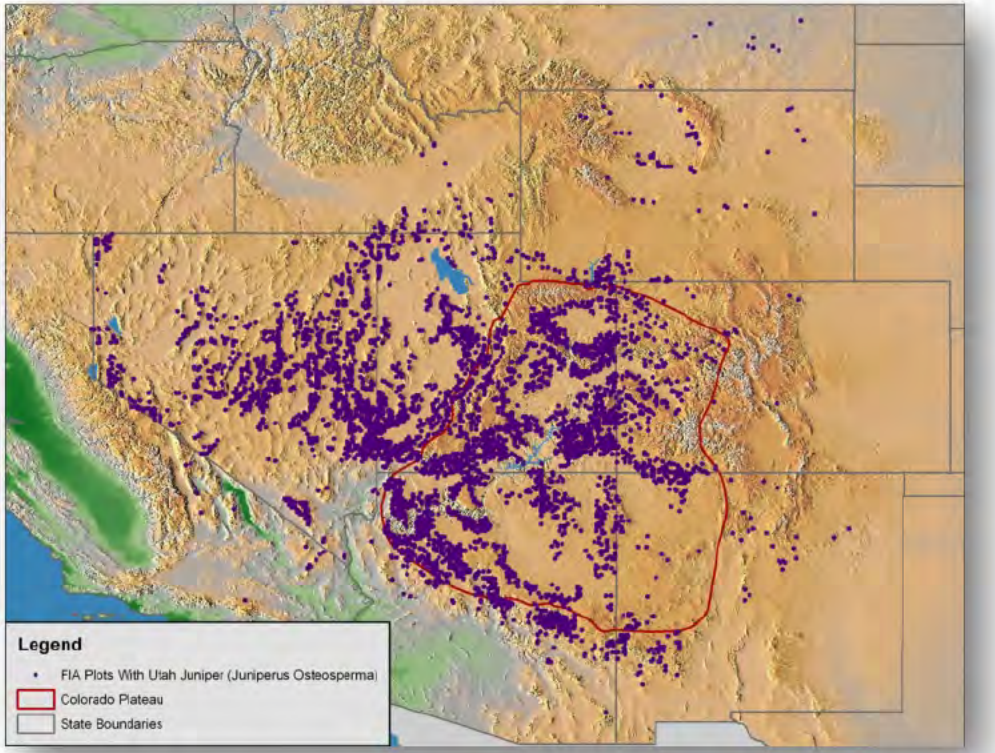
4) Felling, skidding , and delimbing JUOS - $30 to $60/green ton at 450 ft (Dodson, 2010)

Distribution of Utah Juniper (*J. osteosperma*)



(Source: Pinyon-Juniper Woodlands Information Network; FIA Data)

Distribution of Pinyon Pine (*P. edulis*)



(Source: Pinyon-Juniper Woodlands Information Network; FIA Data)

Stewardship Contract

1) Reduce hazardous fuels
2) Restore forest health
3) Reduce tree density
4) Improve biodiversity

Objective of Project

Evaluate the performance, productivity, and cost of a large capacity forwarder moving PJ biomass from a woodland restoration treatment to a landing.

Study Area

Nevershine Hollow

- Bureau of Land Management
- 6500 ft elevation
- Annual rainfall – 12 to 14 in
- Air temp. – 45 to 48 F
- Terrain – 5 to 30% slopes
- 5500 acre PJ treatment area
- 100 to 400+ TPA

Thinning Treatment

1) Leave 30 tpa dbh < 8 inches

2) Leave 8 tpa 8<dbh<18 inches

3) Non-merch. material
(Less than 2 feet above ground)

4) Merchantable material
   - DGL > 8 inches
   - Length > 6 feet

Felling

Feature	Specification
Engine	90 hp
Weight	10,000 lb
Felling head	Shear
Ground pressure	4 psi

CAT 297C Rubber-tracked Skid-steer

Extraction

Feature	Specification
Engine	250 hp Mercedes
Weight	22 tons
Front tires	4 Nokian 710/45
Rear tires	4 Nokain 750/55
Bunk length	16.7 ft; 19 w/ext.
Boom reach	31 ft
Capacity	20 tons

Ponsse Buffalo King 8-wheel Forwarder

Forwarder Operation

Travel empty – Bunk first

Forwarder Operation

Forwarder Operation

Loading/Intermediate travel

Forwarder Operation

Travel loaded

Forwarder Operation

Unloading

Methods (Time Study)

- Travel empty
- Load
- Intermediate travel
- Travel loaded
- Unload

Methods
(Travel distances)

Garmin V GPS

- Travel empty
- Intermediate travel
- Travel loaded

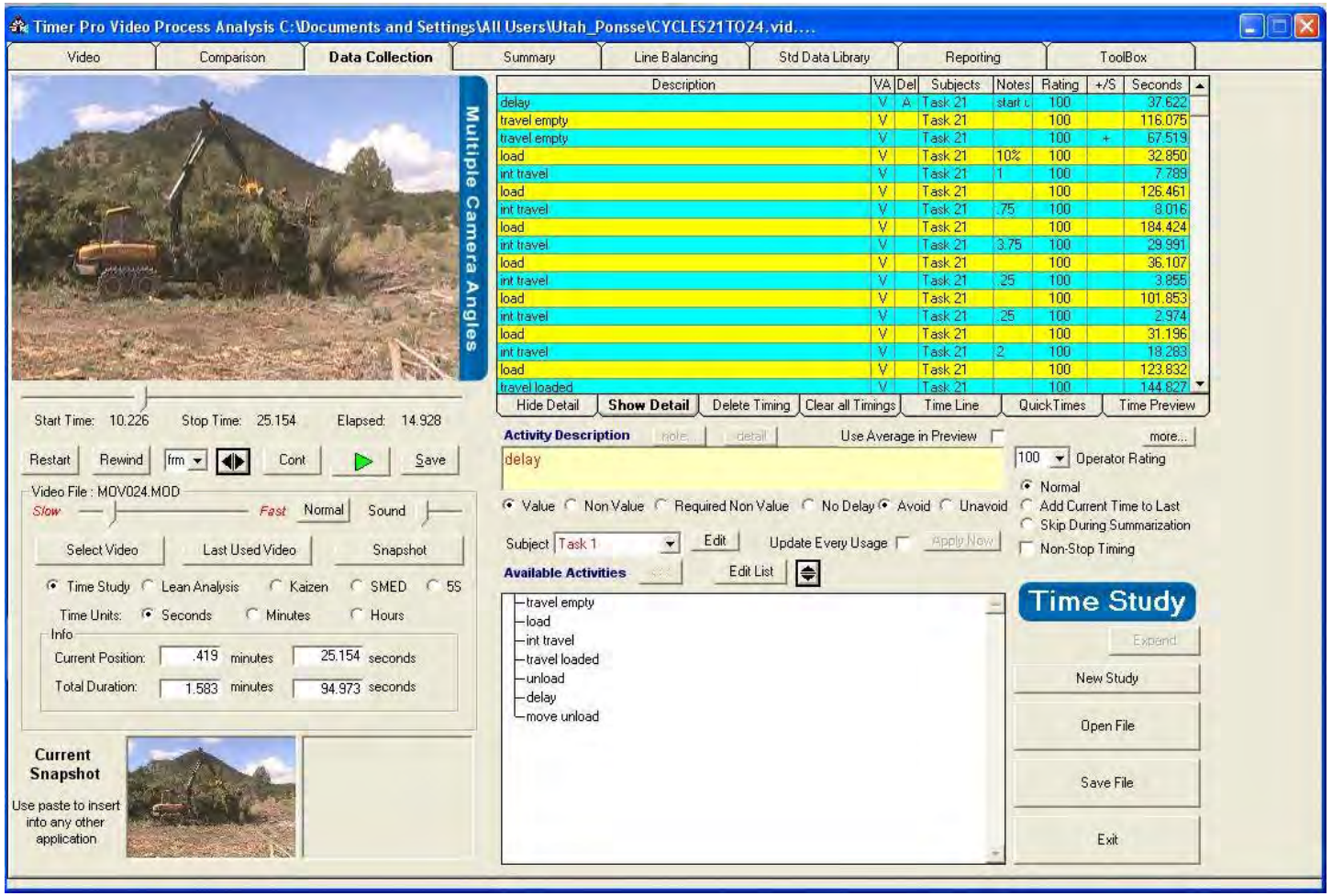
Methods (Load Size)

- Piece count
- DGL estimate
- Number of swings

Methods (Load Size)

- DGL/DBH
- Height to crown base
- Crown width/length
- Total length
- Whole-tree weight

Methods
(Time Study Analysis – Timer Pro)



Methods (Modeling of Elements)

- General Linear Models Procedure (GLM) (SAS Institute Inc., 1988)
- Travel time = f(dist)
- Load and unload time = f(swings, pieces)

Methods (Soil Survey)

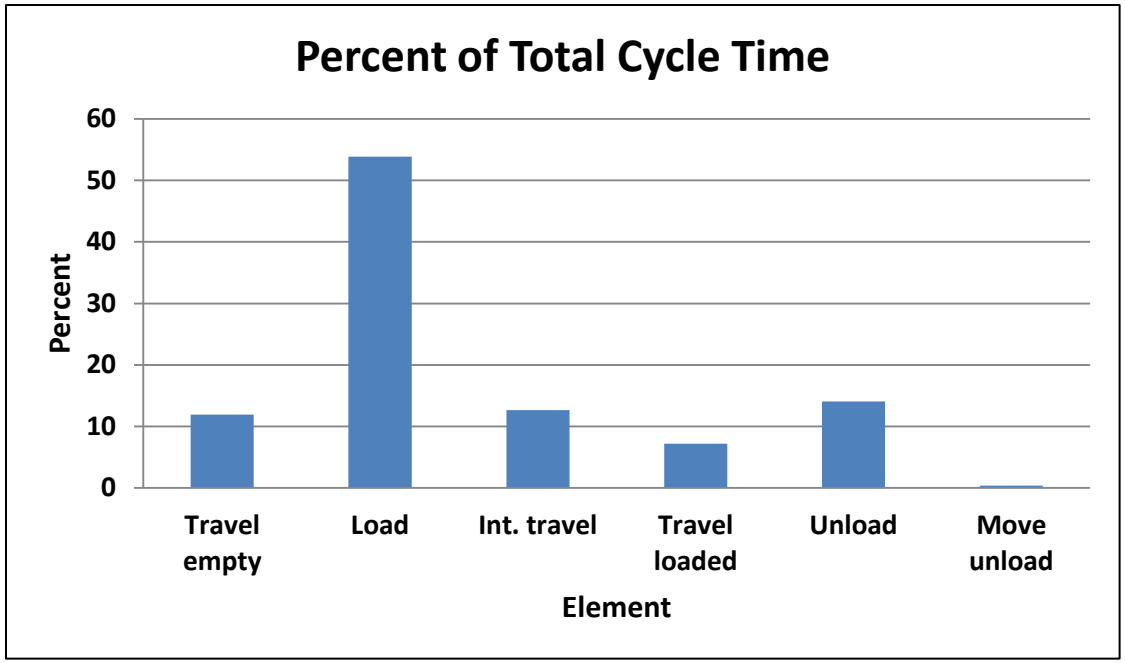
- Point transect method (McMahon, 1995)
- 50 x 20 ft grid
- 5 disturbance classes
  - Undisturbed
  - Trafficked w/litter in place
  - Trafficked w/mineral soil exposed
  - Dragged
  - Deeply disturbed

Results (Time Study)

Variable	N	Mean	SD	Min	Max
Travel empty (min)	47	3.1	1.16	0.9	6.9
Load (min)	47	13.9	3.45	6.7	25.5
Int. travel (min)	47	3.3	2.02	0.1	8.6
Travel loaded (min)	47	1.9	0.99	0.6	5.7
Unload (min)	47	3.6	1.09	0.3	5.9
Move/unload (min)	14	0.3	0.66	0.04	2.6
# Stops	47	7.3	4	1	17
Total time (min)	47	25.7	5.58	14.7	41.7

Results (Elemental Times)

- 32% traveling
- 54% loading
- 14% unloading



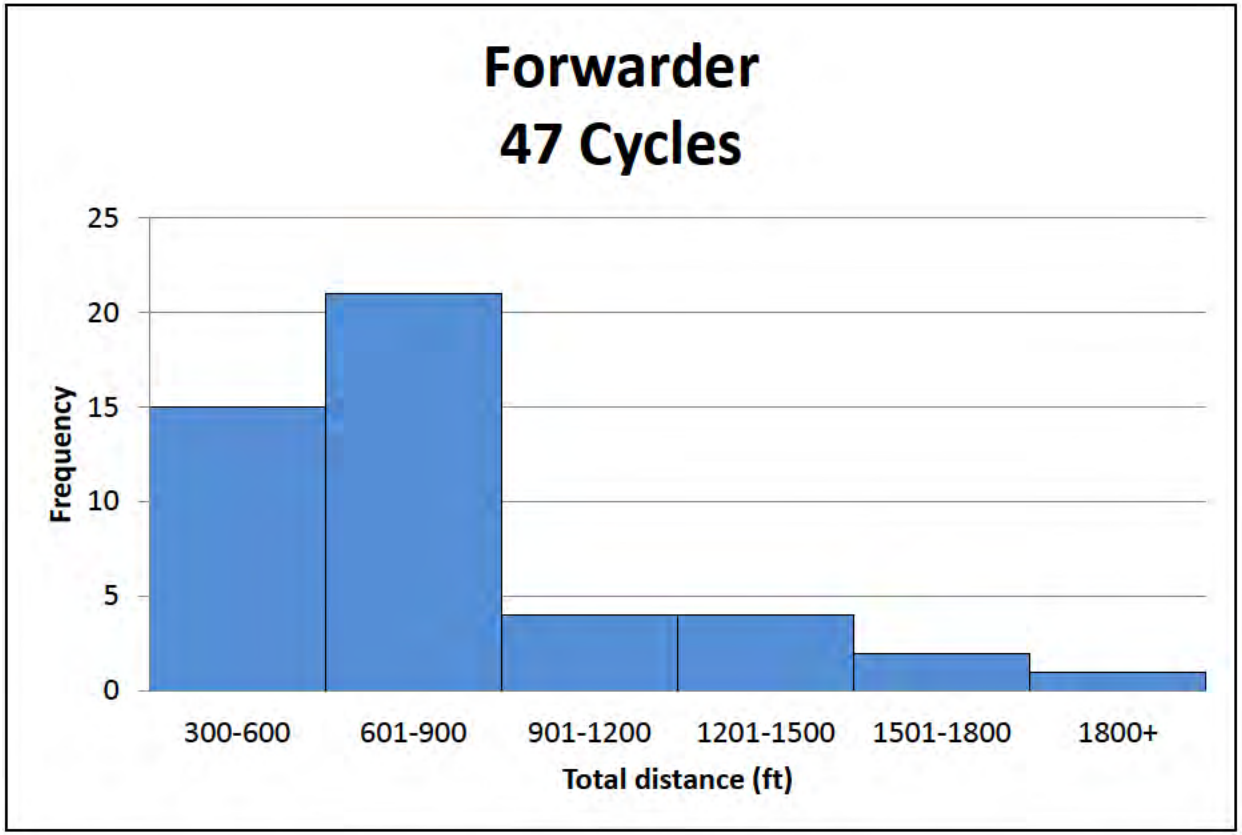
Results (Time Study)

Variable	N	Mean	SD	Min	Max
Empty dist. (ft)	47	517	246.4	175	1604
Int. dist. (ft)	47	312	238.9	4	1191
Loaded dist. (ft)	47	269	145.3	99	636
Total dist. (ft)	47	786	331.1	349	1851
Empty speed (mph)	47	1.9	0.51	0.8	3.2
Loaded speed (mph)	47	1.7	0.38	1.1	2.7

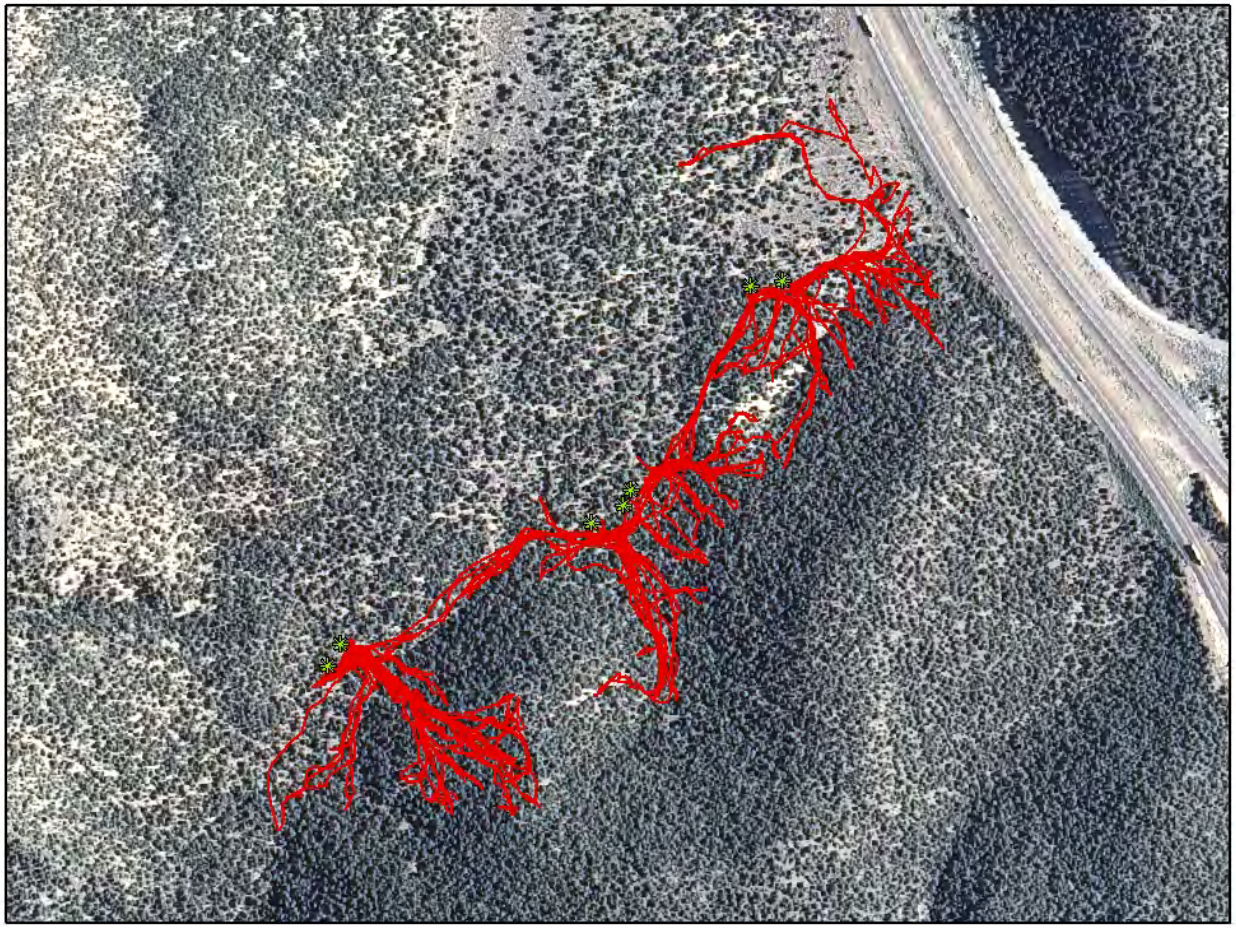
Results (Time Study)

Variable	N	Mean	SD	Min	Max
# swings to load	47	21	6.1	10	39
# swings to unload	47	9	2.3	4	15
# trees per load	47	55	14.9	22	93
Payload (tons)	47	5.1	1.39	2.9	8.6
Productivity (tons/hr)	47	12.1	3.36	6.2	20.5

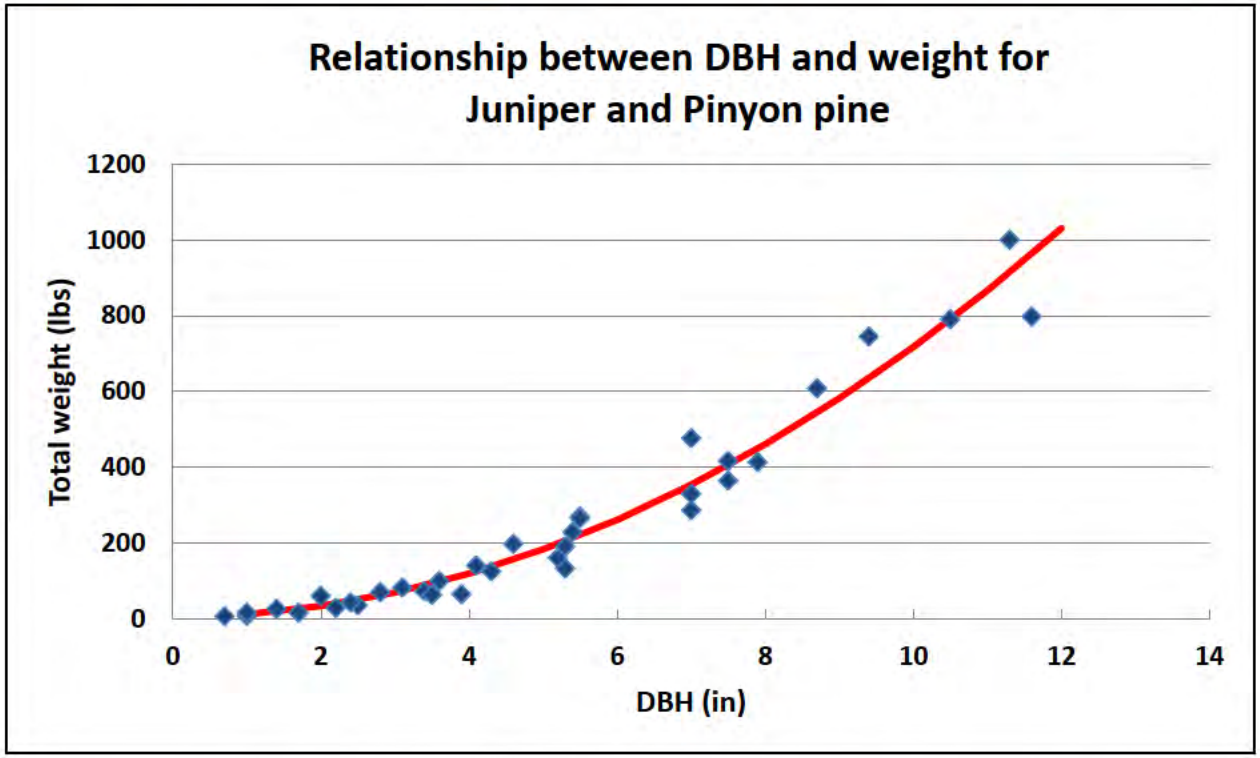
Frequency Distribution



Treated Area



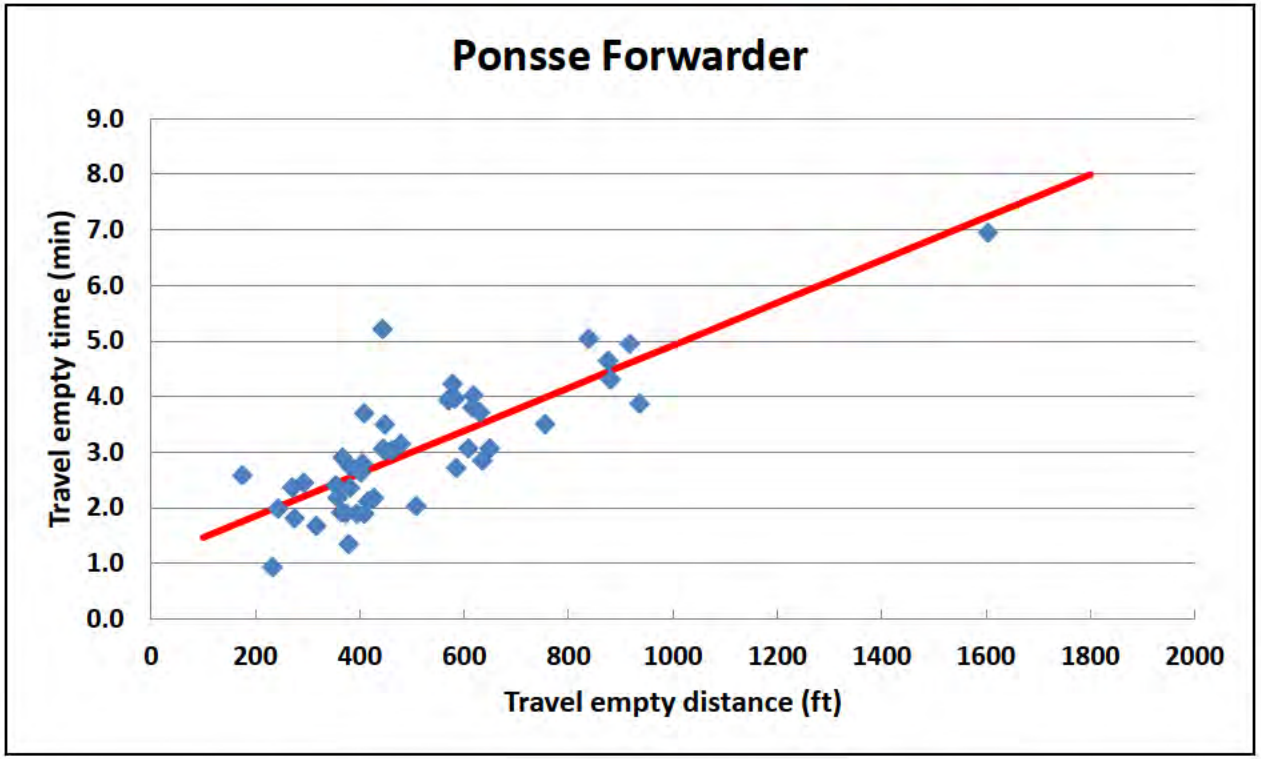
Results (Tree Weight Estimation)



Weight (lb) = (7.124393*Dbh^2)+ 5.01720013

n = 35; R^2 = 0.96;

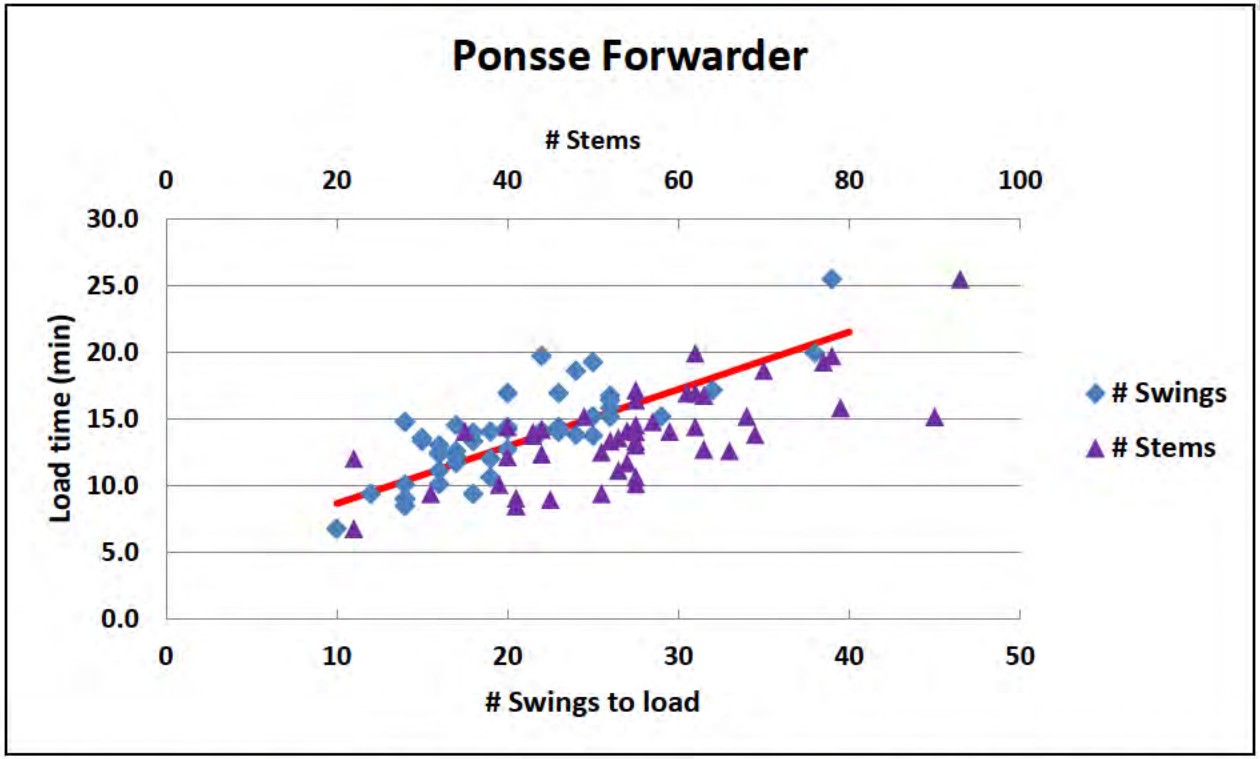
Results (Travel Empty)



TE time (min) = (0.003842*TEDist) + 1.081161

n = 47; R^2 = 0.66

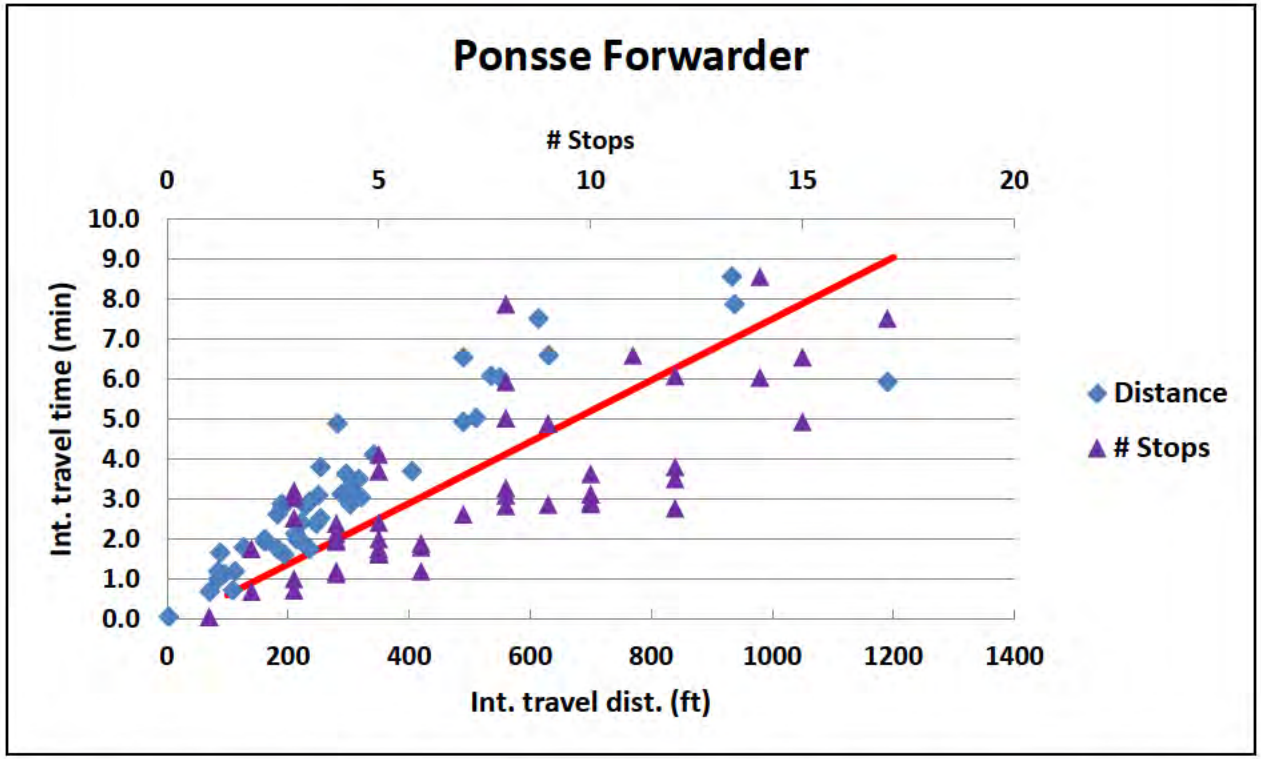
Results (Loading)



Load time (min) = (0.3509478*#swings) + (0.0780867*#stems) + 2.416484

n = 47; R^2 = 0.75

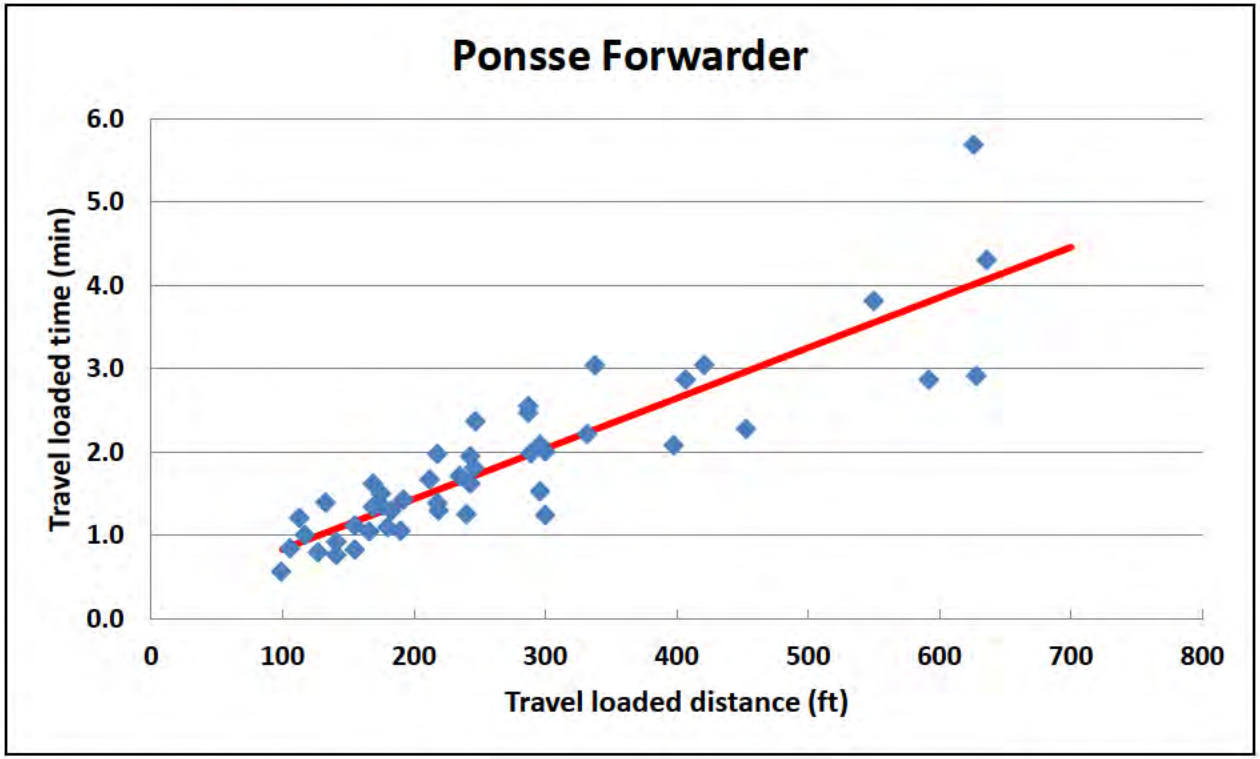
Results (Int. travel)



Int. travel time (min) = (0.00569537*ITDist) + (0.19817789*#stops) + 0.02581422

n = 47; R^2 = 0.90

Results (Travel Loaded)



Travel loaded time (min) = (0.00604292*TLDist) + 0.23092257

n = 47; R^2 = 0.78

Results (Unload)

Confidence Interval Limits	Value
Mean unload time (min)	3.61
Lower limit (min)	3.29
Upper limit (min)	3.93
Confidence level (%)	95
t value	2

Methods
(Costs – General Assumptions)

Variable	Input Data
SMH (Scheduled Machine Hours/yr)	2000
Fuel cost ($/gal)	3.50
Interest rate (%)	10.0
Utilization rate (%)	90

Methods (Costs – Ownership Variables)

Variable	Input Data
Purchase price ($ - less 8 tires)	430,000
Salvage value (% of purchase price)	20
Insurance rate (% of valuation)	1.0
Life (years)	7

Methods (Costs – Operating Variables)

Variable	Input Data
Horsepower	250
Fuel consumption (gal/hr)	3.3
Lube & oil (% of fuel consumption)	6.0
Repair & maintenance (% of depreciation)	35
Tire cost ($)	30,000
Tire life (PMH)	12,000
Labor	
Wage rate ($/SMH)	15
Benefits (% of wage rate)	30

Results – Total Costs

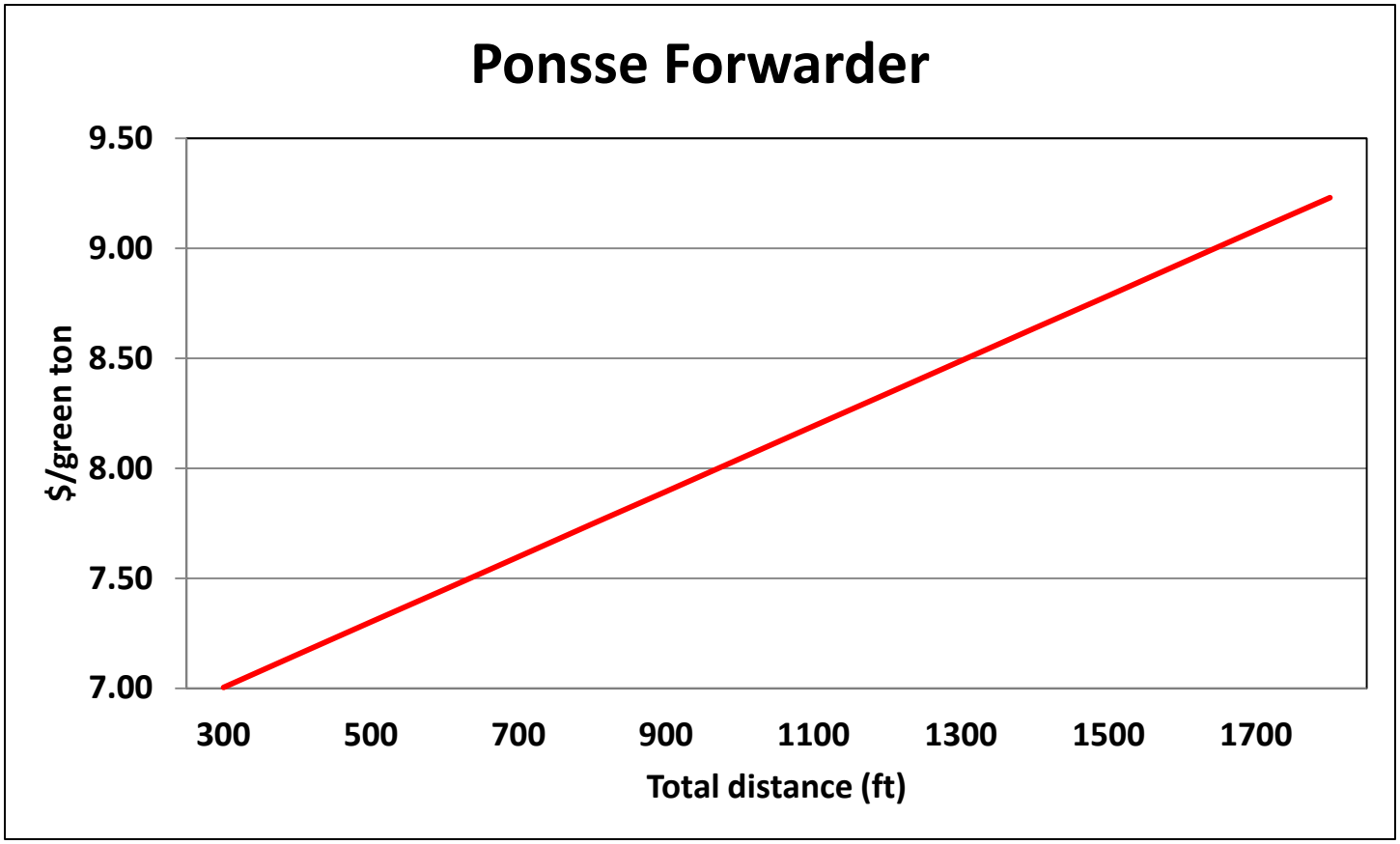
Variable	($US)
Ownership costs ($/SMH)	
Capital	39.63
Insurance	1.41
Total Ownership	**41.04**
Operating costs ($/PMH)	
Fuel	11.51
Oil & lube	0.69
Repair & maintenance	9.56
Tires	2.50
Total Operating	**24.26**
Labor ($/SMH)	19.50
Total costs	
($/SMH)	**82.38**
($/PMH)	**91.53**

Cost Summary

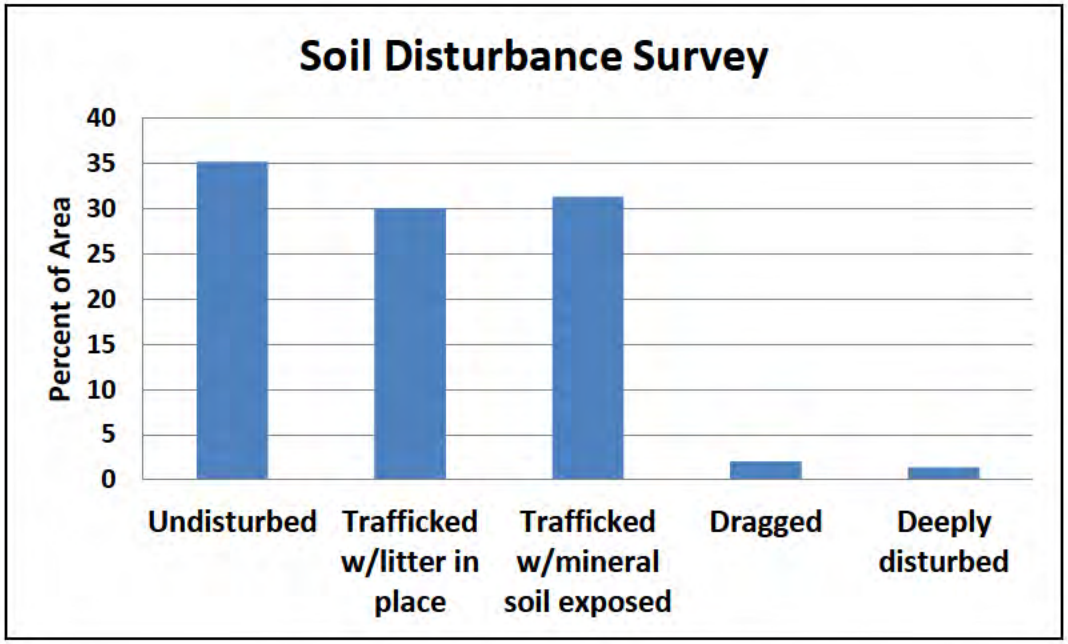
Cost = $91.53/PMH

$/acre	$/green ton
0.42 ac/hr	12.1 tons/hr
$218/acre	$7.56/ton

Results (Productivity)



Results (Soil Survey)



645 total observation points

Conclusions

- Forwarder concept is a relatively simple approach to reducing extraction costs
- Loading time was dominate
- Bunching material could enhance productivity and reduce cost per ton, but comes at the cost of felling productivity
- Forwarder is less sensitive to extraction distance which allows treatments over larger units with fewer roads and landings

Acknowledgements

- Bloomin Ranch Service/Southern Utah Biomass Organization
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- Miller Timber Services, Inc.
- Ponsse

Thank You!