



# **Marginal cost of biomass utilization in mechanized forest restoration treatments in the southwestern USA**

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# Outline

- Regional overview
- Forest restoration
- Harvest systems
- Marginal cost of biomass utilization



# Regional Overview

- ▶ Southwestern USA: Arizona, New Mexico, southern Colorado



# Regional Overview

- ▶ Southwestern USA: Arizona, New Mexico, southern Colorado
- ▶ Monsoon-dominated climate



# Regional Overview

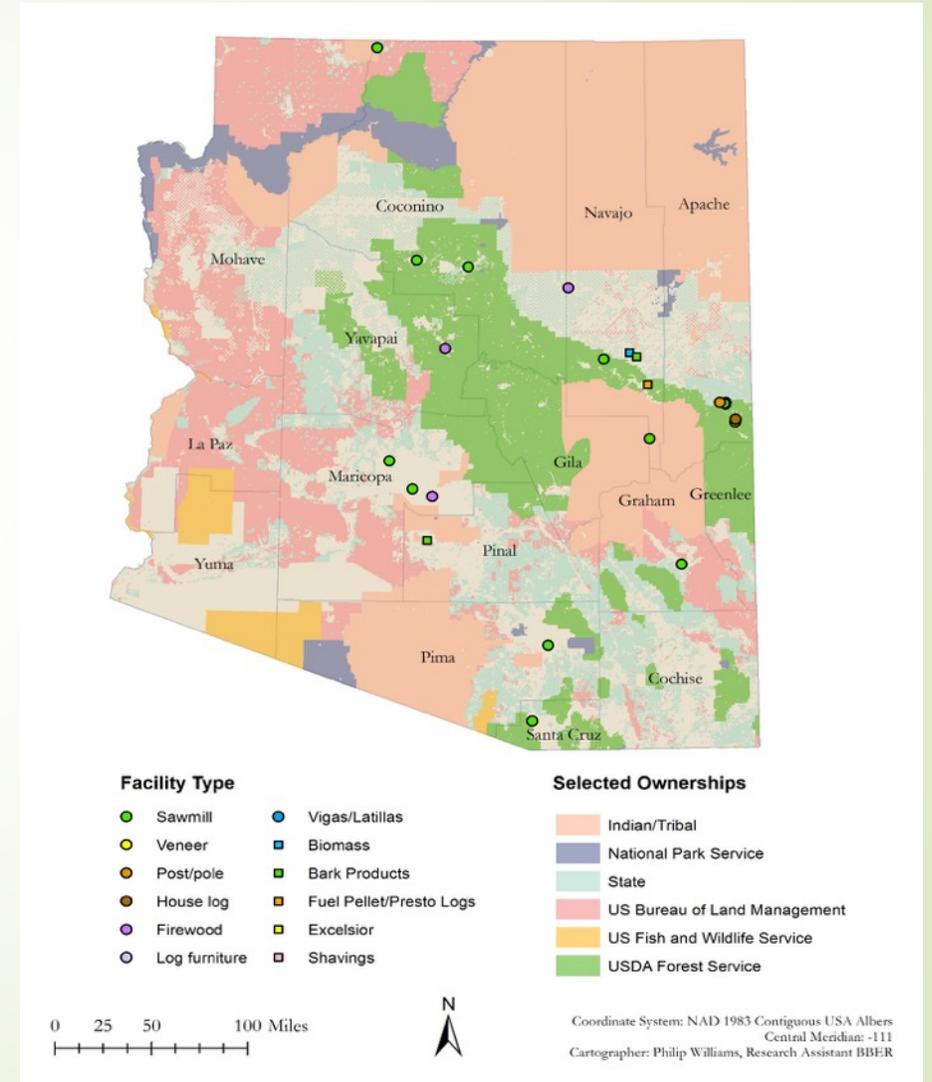
- ▶ Southwestern USA: Arizona, New Mexico, southern Colorado
- ▶ Monsoon-dominated climate
- ▶ Dry pine forests at higher elevations



# Regional Overview

- Southwestern USA: Arizona, New Mexico, southern Colorado
- Monsoon-dominated climate
- Scattered forests at higher elevations
- Limited forest products markets

From: Hayes, S., C. Bingaman, T. Morgan, E. Simmons, K. Marcille, J. Shaw. 2019. The Four Corners timber harvest and forest products industry, 2016. Resour. Bull. RMRS-RB-XXX. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 83 p. (In publication)



# Forest Restoration Need

- ▶ Historic stand structures:
  - ▶ Widely spaced ponderosa pine (*Pinus ponderosa*)
  - ▶ Frequent (3-20 year return interval) low-intensity surface fire



1909 photo from: <https://www.firelab.org/project/century-change-ponderosa-pine-forest>

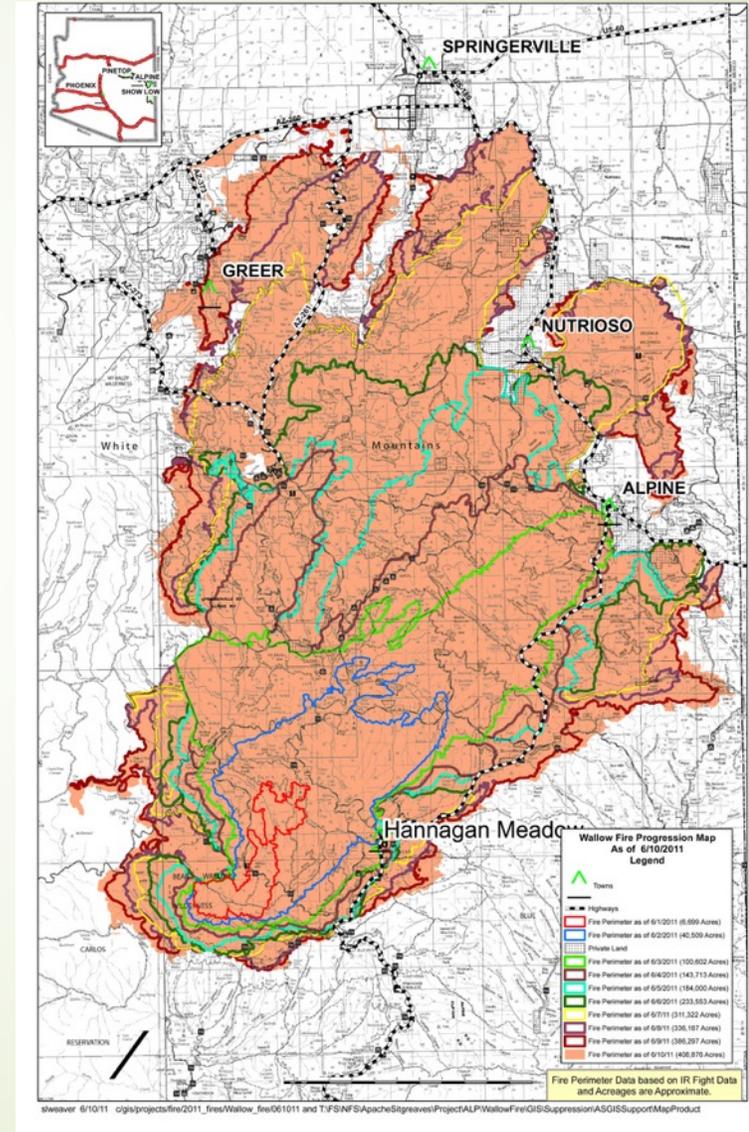
# Forest Restoration Need

- Current stand structures:
  - Century of fire suppression
  - Past logging practices removed large overstory trees
  - Proliferation of small-diameter stems
  - Forests prone to stand-replacing fire



# Forest Restoration Need

- ▶ Large fires have underscored societal recognition of forest restoration need
  - ▶ 2002, Rodeo-Chediski fire burned 1,900 km<sup>2</sup>
  - ▶ 2011, Wallow fire burned 2,177 km<sup>2</sup>



# Forest Restoration Need

- ▶ Forest restoration in the Southwestern US includes:
  - ▶ Decreasing stem density
  - ▶ Increasing heterogeneity of stem spacing
  - ▶ Shifting diameter distribution to larger stems
  - ▶ Reintroduction of frequent, low-intensity fire



# Harvest Systems

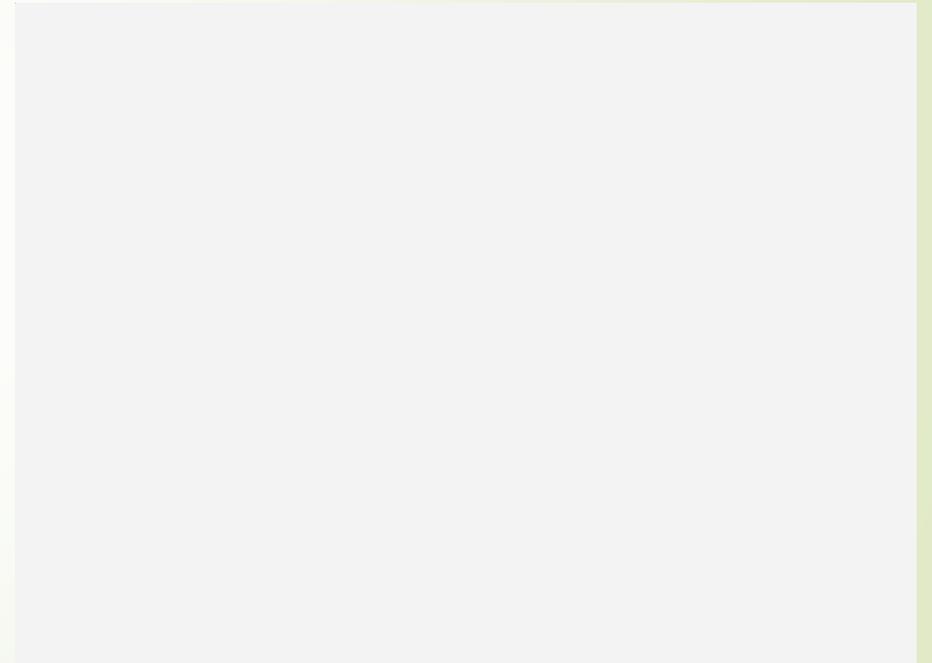
- ▶ Treatment of many small-diameter (low value) stems
- ▶ Options:
  - ▶ Prescribed burn
  - ▶ Lop and scatter
  - ▶ Cut and pile
  - ▶ Whole-tree harvest, burn slash piles
  - ▶ Whole-tree harvest, utilize slash and small-diameter stems as biomass





# Harvest Systems

- ▶ **Forest Bioenergy & Biofuels**  
**Integration:** Sustainability, Energy Balance and Emissions from Forest Restoration in the Southern Rocky Mountains
- ▶ Biomass Research and Development Grant funded by USDA-NIFA
- ▶ 5 contractors evaluated over a 2-year period
  - ▶ Typical of systems in use
  - ▶ Steady flow of forest restoration work under contract



# Arizona: Mechanical whole-tree



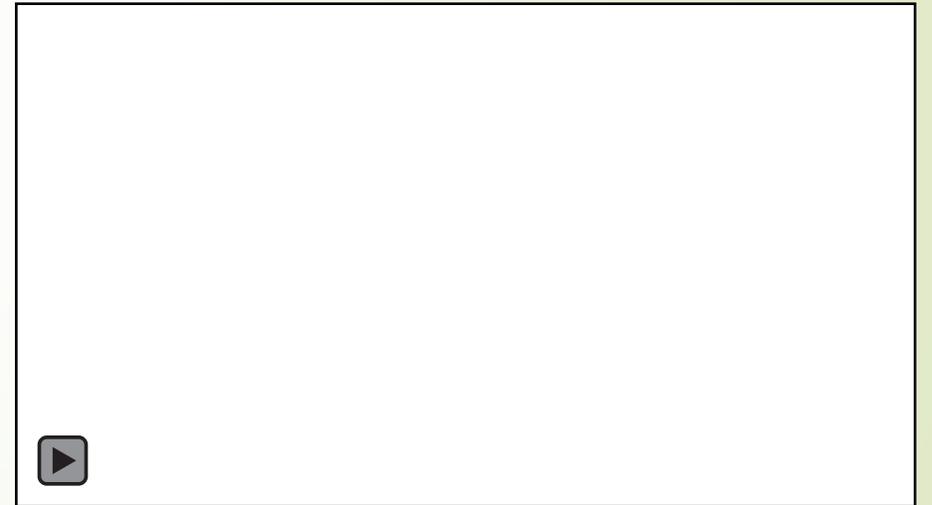
# New Mexico: Modified cut-to-length



# New Mexico: Mechanical whole-tree

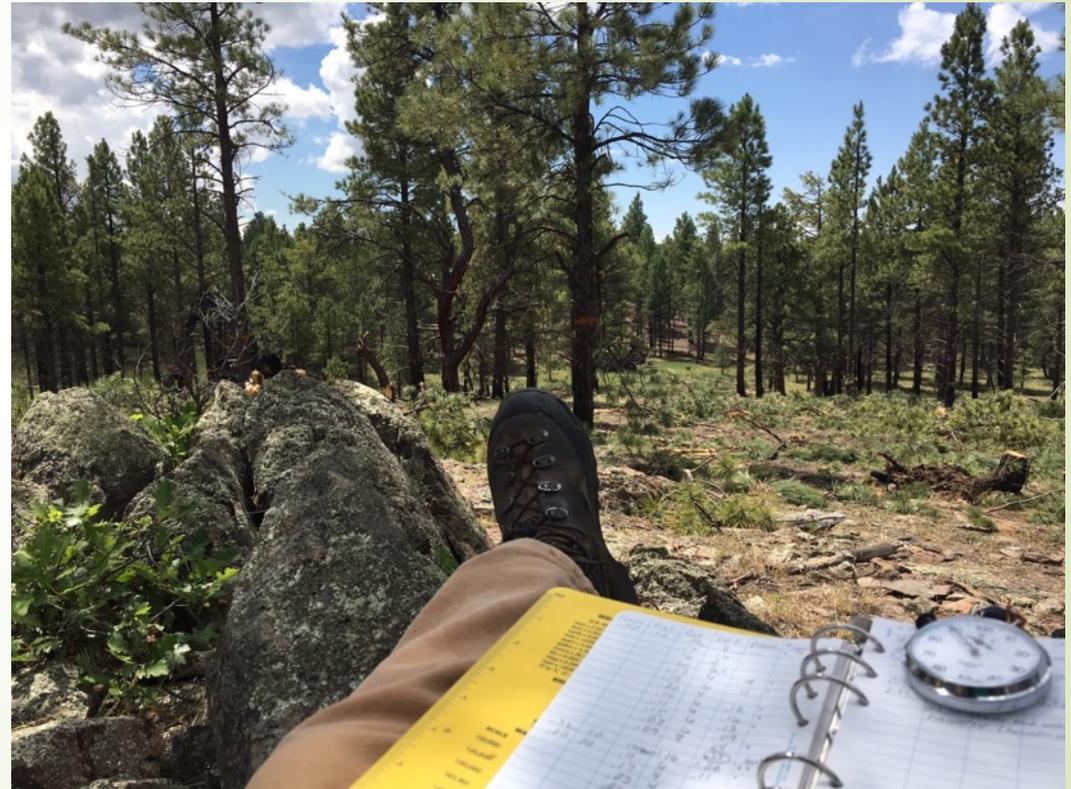


# Southern Colorado: Conventional



# Marginal cost of biomass extraction

- Detailed time-and-motion studies
- 10 operational days per operation
- 2017: state of practice
- 2018/2019: "improved" systems



# Cost results

From: Townsend L. 2019. Harvesting forest biomass in the US southern Rocky Mountains. MS Thesis. University of Montana. 136 p.

Operation	2		3		4	
Year	2017	2018	2017	2018	2017	2018
Function	Observed Costs (\$USD gt <sup>-1</sup> )					
Felling	\$7.74	\$5.83	\$13.17	\$5.85	\$3.76	\$3.08
Skidding	\$11.64	\$3.26	\$11.37	\$3.95	\$4.65	\$4.89
Processing	\$7.38	\$7.19	NA	\$5.07	\$5.89	\$5.56
Cold Decking Loader	NA	\$1.28	NA	NA	NA	NA
Loading	\$2.54	\$2.05	\$9.38	\$3.55	\$3.59	\$2.29
Grinding	\$9.24	\$6.63	N/A	N/A	N/A	N/A
<b>Round wood cost</b>	<b>\$34.97</b>	<b>\$19.61</b>	<b>\$33.93</b>	<b>\$18.43</b>	<b>\$17.89</b>	<b>\$15.82</b>
	Modeled Costs (\$USD gt <sup>-1</sup> )					
Felling	\$4.05	\$3.74	\$12.39	\$4.91	\$4.90	\$4.38
Skidding	\$4.89	\$3.86	\$4.15	\$4.61	\$4.62	\$3.71
Processing	\$5.09	\$6.87	NA	\$3.62	\$8.32	\$7.01
Cold Decking Loader	NA	\$2.03	NA	NA	NA	NA
Loading	\$2.54	\$2.05	\$9.38	\$3.55	\$3.59	\$2.29
Grinding	\$9.24	\$6.63	N/A	N/A	N/A	N/A
<b>Round wood cost</b>	<b>\$16.57</b>	<b>\$18.54</b>	<b>\$25.92</b>	<b>\$16.69</b>	<b>\$21.43</b>	<b>\$17.40</b>

# Marginal cost of biomass extraction

- ▶ How much does it cost to treat small-diameter stems at the same time as “merchantable” stems, using common commercial logging systems?



# Marginal cost of felling: Case 1

- ▶ 2017: Segregated felling on Operation 2
  - ▶ 618 stems/ha <10 cm vs. 404 stems/ha > 10 cm
  - ▶ 7.1 stems/minute cut < 10 cm vs. 2.9 stems/minute > 10 cm
  - ▶ @\$133/hr for wheeled hotsaw: **\$192/ha**
  - ▶ Assuming 500 stems/ha: **\$156/ha**



# Marginal cost of felling: Case 2

- ▶ Between 2017 and 2018, contract specifications for Operation 4 changed: no longer required to cut <10 cm
  - ▶ Decrease in felling cost of \$0.52/tonne
  - ▶ No statistical difference in time to cut vs. DBH: 0.0644 min stem<sup>-1</sup>
  - ▶ 280 stems/ha <10 cm, \$187/hr: **\$56/ha**
  - ▶ Assuming 500 stems/ha: **\$100/ha**



# Marginal cost of skidding

- ▶ 2017: Operation 2 segregated skidding by product type
  - ▶ 618 stems/ha <10 cm, \$143/hr:  
**\$707/ha**
  - ▶ Assuming 500 stems/ha < 10 cm:  
**\$572/ha**



# Comparison of alternatives

- ▶ In conjunction with sawlog harvest: \$875-925/ha
- ▶ Motor-manual thinning: \$700-1850/ha
- ▶ Mastication: \$1000-2500/ha
- ▶ Prescribed burn: \$300-1200/ha
  
- ▶ Utilization of biomass: grinding averaged an additional \$6.63/tonne



# Conclusion

- ▶ If removal of other products is prescribed: treating small-diameter stems using a traditional harvest system is likely the most economically-efficient option
  - ▶ Particularly when using a hotsaw vs. harvester/bar saw
- ▶ This study allows for better cost data when considering alternatives

