forestconcepts™

Conceptual Specification of Large-Bale Forest Residue Balers

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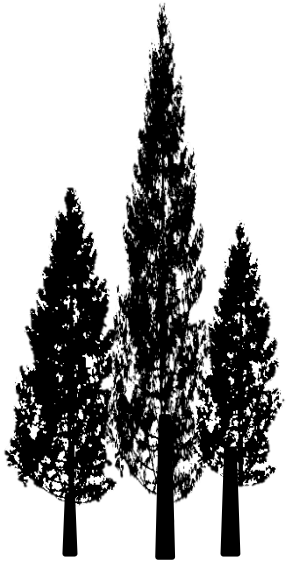
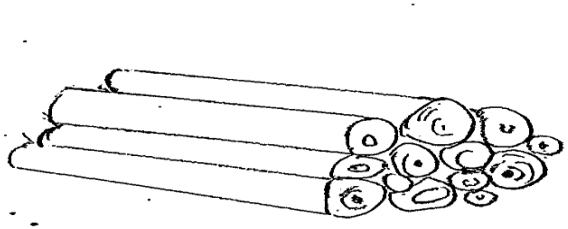
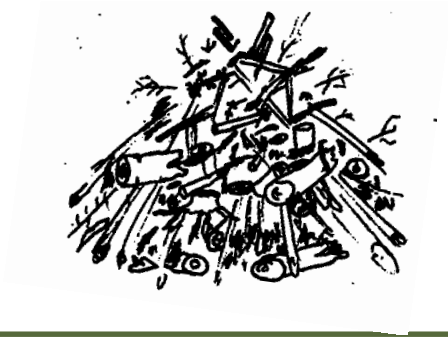
Forest Residues Problem

- Increasing volumes of slash in piles and landings
- Mechanized harvest, delimbing
  - Less chainsaw work in the brush to increase feller productivity and safety > more brush at landing
- Restrictions on open burning
- Risks of slash fire escapes
- Loss of forest productivity
  - under burned piles due to soil heating
  - Under unburned piles and clumps due to soil cover





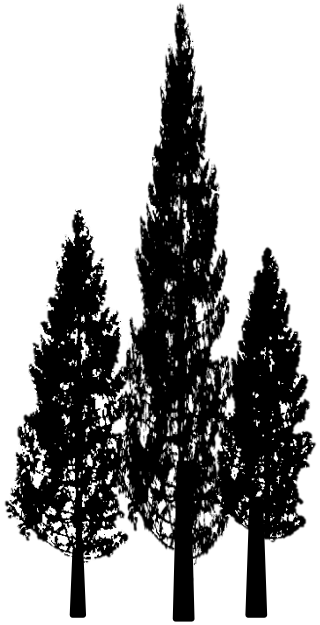
Sawlogs



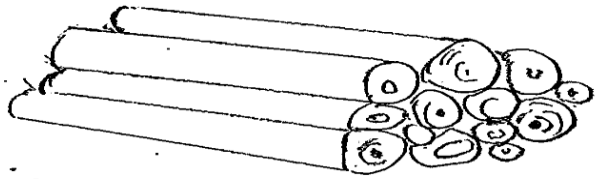
Forest residues

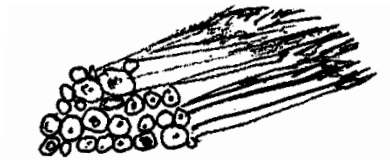
No sorting (current practice)

Sorting tree tops



Sawlogs





Processed tops

Slash piles

Why Bale? Operational Objective: Enable cost-effective collection of branches & tops

Why Bale? Economic Objective:

Enable cost-effective transportation, storage, and processing

Arborist Chipper Replacement Baler
Wildland Urban Interface – Deschutes County, OR

Deschutes NF field demo with
Forest Resources Association,
Friends of the Metolius
City of Bend,
USFS R6 Staff

Yakama Forestry Burn Piles

NARA OSU Springfield Trial January 2014

- Summary data from the trial includes:
- 37 total bales weighing 36.85 green tons
  - Truckload limit = 48 bales (cube) or 32 tons (weight)
- Average bale weight 1,992 pounds, average density 26.8 lb/ft^3
- Highest bale weight = 2,304 pounds, highest bale density = 32.6 lb/ft^3
- Average time to bale = 28 minutes, average time to tie = 13 minutes
- Fastest time to bale = 21 minutes, fastest time to hand tie = 7 minutes
- Moving and repositioning between bales took 2-4 minutes

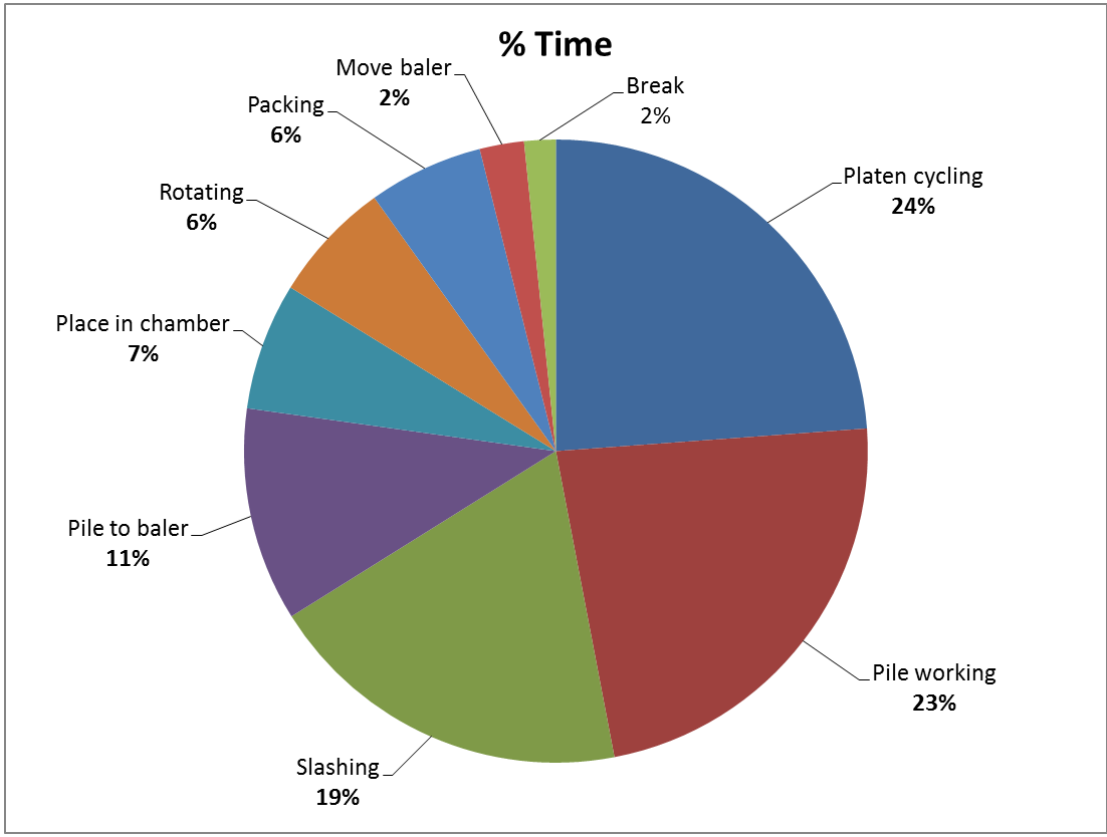
Moment-Method Modeling of Baling Time

Biomass baler productivity data forestconcepts

Date:	January 29-30, 2014										
Location:	Springfield, Oregon NARA Logging slash baling experiments										
Conditions:	operating at Weyerhaeuser TOPS yard from windrowed material							Avg. Bale		Potential	
	Percentage of total time							Minutes		Minutes	
Operation	**1**	**2**	**3**	**4**	**5**	**Avg**	**st dev**	**28**	**st dev**		
pulling pile apart	5%	9%	8%	0%	0%	4%	4.2%	1.2	1.2	1.2	
getting grapple load	23%	28%	14%	23%	29%	23%	5.9%	6.5	1.7	3.5	concurrent with push
rebunching/drop& rebunch	2%	2%	0%	0%	0%	1%	1.1%	0.2	0.3	0.0	better grapple end
waiting for ground crew	0%	0%	0%	0%	0%	0%	0.0%	0.0	0.0	0.0	
slashing grapple grip	14%	11%	17%	19%	13%	15%	3.4%	4.1	1.0	4.1	
Loading	14%	17%	11%	10%	16%	14%	3.1%	3.8	0.9	3.8	
Packing	6%	9%	8%	3%	3%	6%	2.6%	1.6	0.7	0.8	better cycling
rejiggering material in baler	6%	0%	8%	6%	0%	4%	3.9%	1.2	1.1	1.0	better cycling
waiting for baler cycle	31%	26%	33%	39%	39%	33%	5.6%	9.4	1.6	2.8	70 % time reduction
waiting - other	0%	0%	0%	0%	0%	0%	0.0%	0.0	0.0	0.0	
total	100%	100%	100%	100%	100%		bale	28		17.2	
							tie	13		3.0	autotie
					min/dy		total	41		20.2	
					440	8 hr day		10.7		21.8	bales/day
					550	10 hr day		13.4		27.2	bales/day

Work Element Pie Chart

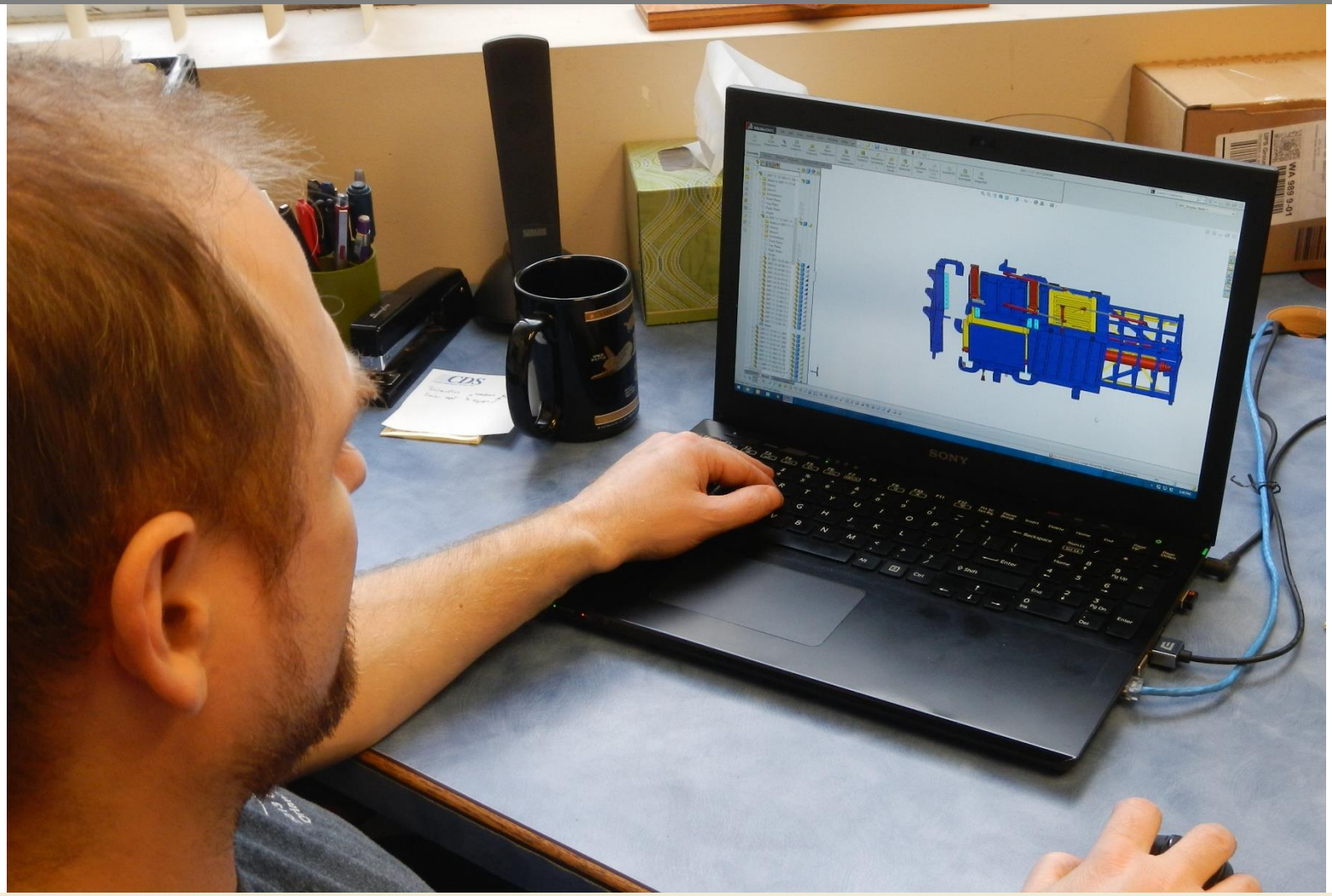
- 2015-08-19 Baling Field Trial
- Snoqualmie Pass, WA



Biomass Baling - Minimize costs for collection, handling, storage, and shipping

- Higher density is better:
  - reduces storage space,
  - increases transport payload,
  - enables more efficient grinding
  - Trade-off against heavier baler and more fuel consumption by baler
- Rectangular bales are better:
  - handling just like other baled recyclables and hay
  - use of conventional bale handling equipment
  - safer stacking on trucks and in bale-yards

Design of a Baler



Baling Research Equipment

Lab Baler (the Squid)

Pilot Scale Baler (Load King)

Mobile Engineering Prototype Baler (Bighorn Baler®)

the practice of engineering is as much negotiation and compromise as it is analytic

Louis Bucciarelli

Designing Engineers

Who Cares?

Influencers & Constraint Owners	Direct Stakeholders
Landowner / Land Manager	Baler Owner
Forester/Logging Supervisor	Baler Operator
Forest Operations Contractor	Baler Mechanic
Biomass Hauling Contractor	Baler Manufacturer
Biomass Bale-Yard Manager	Baler Hauler (mobilization and moving)
Forest Operations Safety Regulator	Equipment Dealer/Parts-Service Provider
Fire Protection Regulator	Bale Hauling Truck Driver
Invasive Species & Diseases Regulators	Bale Handling Equipment Operator
Insurance Carrier	Biomass Grinder Operator
Financial Institution/Credit Provider	
Environmental Sustainability Interests	
Bioenergy Advocacy Interests	
Forest Products Certification Bodies	

What's Important to Them?

- Safety – everyone defines safety in their own context
- Cost of ownership and operation
- Bale size, shape, weight, durability, …
- Productivity of baler and "system" in the context of operational requirements
- Bale processing implications with horizontal or tub grinders
- Bale logistics system complexity from logging unit to end user
- Maintenance intensity and complexity
- Noise, dust, …
- Necessary minutia – fuel type, spark arresters, controls, …

Customer Requirements are Bimodal Need Two Basic Baler Models

- Highly mobile & agile system to recover small spatially dispersed piles – 80% of the machines, 40% of the biomass
  - 0.3 - 3 tons per pile or roadside windrow
  - Piles 10 – 1,000 meters apart
  - Objective: Biomass removal at a reasonable cost
- High production system for large piles at landings with good truck access – 20% of the machines, 60% of the biomass
  - 20 - 200 tons per pile or continuous large windrow
  - Biomass forwarders may bring piles from 1-km radius to the baling operation
  - Objectives:
    - Highest production rates with low operating cost per ton baled
    - Provide alternative to in-woods grinding and bulk hauling

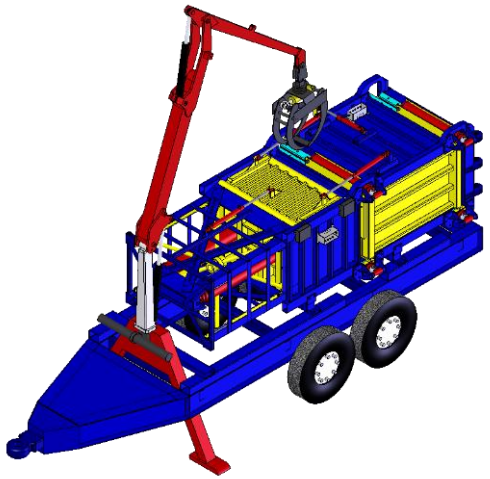
Other Stakeholder –Driven Top-Level Design Specifications

- Minimize operators
  - Wireless remote-operate from tracked grapple-loader
  - Eliminate ground crew and human chainsaw operators
- Minimize cost and time for moving to and within forest
  - Physical size does not require oversize load permits
  - Gross weight does not require overweight load permits
  - Enable transport under a range of contractor operating paradigms
- Modular baler unit
  - Baler independent of carrier to enable mounting on “anything”
  - Forwarder, 6x6 truck chassis, tracked undercarriage, hook-lift frame

Forest Biomass Utility Baler

Baling roadside slash from forest thinnings
Snoqualmie National Forest (Aug 2015)

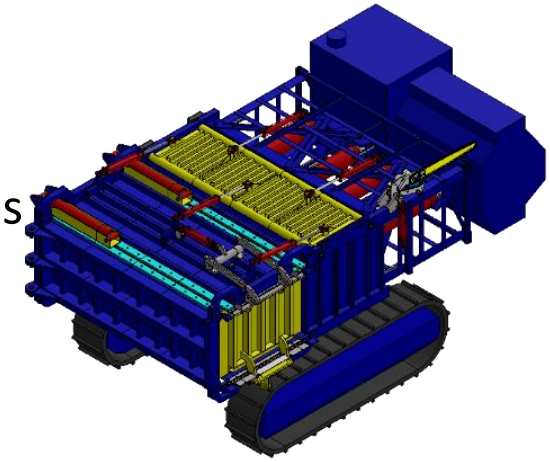
- Modular baler unit that can be mounted to:
  - On-road or off-road trailer
  - Log forwarder
  - Tracked undercarriage
  - Truck chassis or flatbed truck
  - Hook-lift skid
- Bale size and weight optimized for:
  - Skid-steer loader handling
  - Smaller Peterson* horizontal grinders
- Primary uses:
  - Baling roadside windrows and supporting thinning crews
  - Baling slash from keyhole and stranded landings
  - Recovering dispersed slash



Forest Biomass Large Baler (conceptual)

- Modular baler unit that can be mounted to:
  - Tracked undercarriage
    - remote-operated by loader)
  - Off-road/mining truck chassis
  - Log forwarder
  - On-road or off-road trailer
- Bale size and weight optimized for:
  - Track-hoe and off-road forklift handling
  - Largest Peterson* horizontal grinders
- Primary uses:
  - Baling piled slash at cable and ground logging sites
  - Baling dispersed slash piles within units and secondary roads
  - As an alternative to in-woods grinding

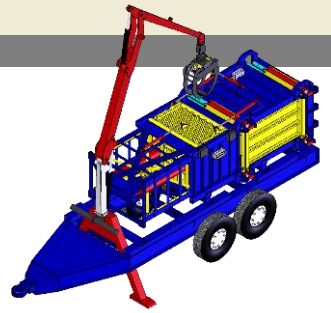
Conceptual tracked baler drawing on actual biomass recovery operation at Arcata, Calif.
Current bulk biomass forwarder shown to left of loader.



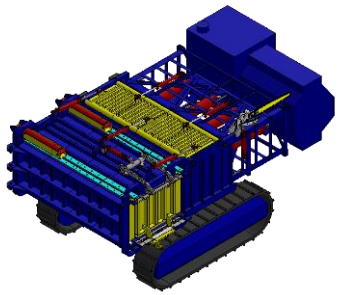
Conceptual Forest Residuals Balers

(Updated October 1, 2015)

		Conceptual BRDI Project Balers		
	FCLLC Engineering Prototype (FCEP)	Urban Chipper Replacement	Forest Biomass Utility Baler	Forest Biomass Large Baler
Bale Size (inches)	32x48x56	36x48x72	32x48x56	34x48x96
Bale Density (lb/cu.ft – @ 50% MC wb)	15-25	15-20	20-30	20-30
Bale Weight (lb)	800 – 1,400	1,000 – 1,400	1,000 – 1,500	2,000 – 2,700
Loader	Self-loading grapple	Self-loading grapple	Self-loading grapple	Track-hoe with brush grapple
Theoretical/Operational Capacity (bales/hr)	3/2	5/3	10/4	18/10
Horsepower	28	49	49	260
Crew	2 (manual tie)	2 (manual tie)	1 (auto-tie)	0 (remote-operated)
Running Gear	5th Wheel Trailer	Category 3 trailer	Modular	Tracked
Capital Cost ($) Est.		$110,000	$130,000	$350,000



Forest Biomass Utility Baler



Forest Biomass Large Baler

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Thank You

www.forestconcepts.com

* **Peterson is a brand of Peterson Pacific Corporation**
Mention of corporations or brand names does not constitute an endorsement or recommendation.

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