

# Estimating Harvest Costs and Product Values for Southwest Ponderosa Pine

Dennis R. Becker, PNW Research Station  
Debra Larson, Northern Arizona University  
Eini C. Lowell, PNW Research Station  
Robert B. Rummer, SRS Research Station



# Research Cooperators

## Joint Fire Science Program



- In-woods Decision Making of Utilization Opportunities to Lower Costs of Fire Hazard Reduction Treatments
- 3-year program, Fall 2005 scheduled completion

## Southern Research Station

- Elemental time and motion studies
- Machine and system productivity



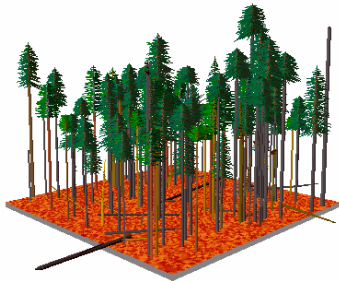
## Northern Arizona University

- Project appraisal decision support tool
- Log generator and product recovery model

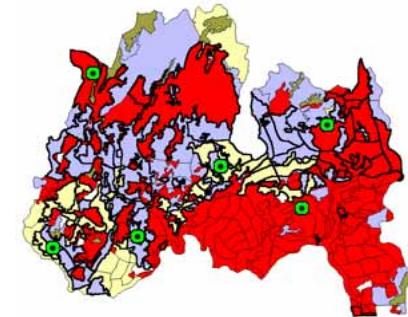
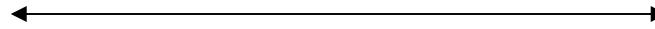




# Decision Support Tools



**Detailed  
Engineering  
Models**



**Broad Policy &  
Planning  
Applications**

Volume by DBH  
Fuel Reduction Rx  
Merchantable Volume  
Machine Set  
Product Markets



# Decision Support Tools

## Harvest Cost & Revenue Estimator

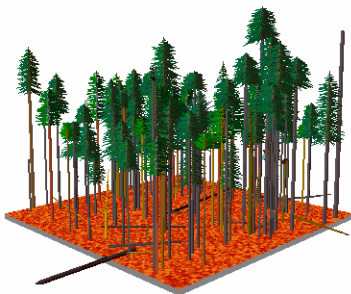
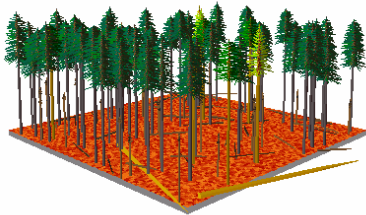
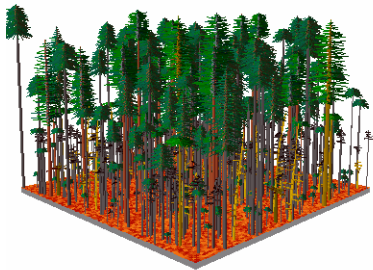
### USER-INPUT

- Cut tree data (by DBH)
  - Harvest system
  - Machine model, age, price
  - Machine hp, years owned
  - Wage rates, benefits
  - Mobilization distance
  - Existing market(s)
  - Log market specifications
  - Distance to market
  - Desired profit margin
- Log generator (ccf, bf)
  - Merchantable/sub-merchantable
  - Production rates by machine type
  - Machine O&M costs
  - Mobilization costs
  - Transportation, handling costs
  - Revenue potential of raw material
  - Cost-to-revenue comparison



# HCR Estimator

## Stand-level estimator of revenue



Small diameter  
ponderosa pine  
in the  
Southwest

### **Timber sale staff**

Project appraisal

Contract review

### **Regional Office**

Stumpage values

Diameter cap restrictions

### **Contractors**

Detailed harvest costs

Market assessment

# Input Details

Microsoft Excel - Unit273April.xls

File Edit View Insert Format Tools Data Window Help

K34 =

	A	B	C	D	E	F	G
2	<b>HCR Estimator - Southwest PIPO</b>						
4				<b>Cutting Activity</b>			
5				DBH Class		Cut	
6	<b>Project Description</b>			(in)		TPA	
7	Prject Name	Unit 273		1		12.6	
8	Number of acres	37		2		6.9	
9	Average ground slope (%)	2.00%		3		6.9	
10	Species Composition	PIPO		4		10.9	
11	Existing (tpa)			5		11.7	
12	Details			6		8.1	
13				7		10.1	
14	<b>Contract Specifics</b>			8		15.4	
15	<b>Bid rate for merchantable volumes</b>			9		15.4	
16	\$/ccf	\$7.61		10		10.5	
17	<b>Service contract bid</b>			11		12.1	
18	\$/acre	\$371.00		12		8.1	
19	Thinning sub-merchanatable?	TRUE		13		9.7	
20	<b>Indirect costs (estimate % of total costs)</b>			14		8.5	
21	Office overhead	10.00%		15		4.9	
22	Road work, seeding, water barring, misc.	2.62%		16		0.0	
23	Desired profit	10.00%		17		0.4	
24	<b>Brush &amp; Slash Specification</b>			18		0.0	
25	Scattered & Loped?	FALSE		19		0.0	
26	Machine piling piles in woods?	TRUE					
27	Remove to landing?	FALSE					
28							



# Log Calculator

**What size of ponderosa pine tree,  
in DBH, do you need to  
produce the following log?**

**Market 1:** 6-in small-end diameter,  
16'ft length

**Market 2:** 4-in small-end diameter,  
12-ft length

# Market 1: 6-in SED, 16-ft length

12					Butt	tree-log	Length	Tree vol									
13					Log	w.w. dia	to top	to top	Viable	length	ending	Merc	Scrib		Merc	Merc	
14	DBH Class	Cut	Ht	BA/tree	end dib	taper	6	6	log?	for vol	dia	vol	log	Logs	vol	vol	
15	(in)	TPA	(ft)	(ft)	(in)	(in/ft)	(ft)	cf/tree	(/tree)	(ft)	(in)	cf/log	Bf/tree	per ac	bf/ac	cf/ac	
16	1	12.6	8.88	0.01	1.02	0.0555	0.00	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
17	2	6.9	14.51	0.02	2.00	0.0656	0.00	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
18	3	6.9	19.80	0.05	2.97	0.0757	0.00	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
19	4	10.9	24.76	0.09	3.94	0.0858	0.00	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
20	5	11.7	29.41	0.14	4.91	0.0959	0.00	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
21	6	8.1	33.77	0.20	5.88	0.106	0.00	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
22	7	10.1	37.86	0.27	6.85	0.1161	7.36	1.66	0	0	0.00	0.00	0	0.00	0	0.00	
23	8	15.4	41.70	0.35	7.83	0.1262	14.47	3.80	0	0	0.00	0.00	0	0.00	0	0.00	
24	9	15.4	45.31	0.44	8.80	0.1363	20.53	6.20	1	20.53	6.00	6.20	16	15.40	246	95.54	
25	10	10.5	48.69	0.55	9.77	0.1464	25.75	8.90	1	25.75	6.00	8.90	20	10.50	210	93.45	
26	11	12.1	51.86	0.66	10.74	0.1565	30.30	11.89	1	30.3	6.00	11.89	24	12.10	285	143.88	
27	12	8.1	54.83	0.79	11.71	0.1666	34.30	15.18	1	34.3	6.00	15.18	27	8.10	216	122.98	
28	13	9.7	57.63	0.92	12.69	0.1767	37.84	18.78	1	37.84	6.00	18.78	29	9.70	285	182.19	
29	14	8.5	60.24	1.07	13.66	0.1868	40.99	22.69	1	40.99	6.00	22.69	32	8.50	271	192.88	
30	15	4.9	62.70	1.23	14.63	0.1969	43.83	26.91	1	41	6.56	26.31	32	4.90	156	128.90	
31	16	0	0.00	0.00	0.00	0	0.00	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
32	17	0.4	67.17	1.58	16.57	0.2171	48.70	36.31	1	41	7.67	34.34	32	0.40	13	13.74	
33	18	0	0.00	0.00	0.00	0	0.00	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
34	19	0	0.00	0.00	0.00	0	0.00	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
35	Total	152.2						ave mer tree cf	14.09					69.6	1682.4	973.6	

**69.6 logs/acre or 1.005 truckloads/acre**

# Market 2: 4-in SED, 12-ft length

12					Butt	tree-log	Length									
13					Log	w.w. dia	to top	Viable	length	ending	Merc	Scrib		Merc	Merc	
14	DBH Class	Cut	Ht	BA/tree	end dib	taper	4	log?	for vol	dia	vol	log	Logs	vol	vol	
15	(in)	TPA	(ft)	(ft)	(in)	(in/ft)	(ft)	(/tree)	(ft)	(in)	cf/log	Bf/tree	per ac	bf/ac	cf/ac	
16	1	12.6	8.88	0.01	1.02	0.0555	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
17	2	6.9	14.51	0.02	2.00	0.0656	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
18	3	6.9	19.80	0.05	2.97	0.0757	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
19	4	10.9	24.76	0.09	3.94	0.0858	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
20	5	11.7	29.41	0.14	4.91	0.0959	9.50	0	0	0.00	0.00	0	0.00	0	0.00	
21	6	8.1	33.77	0.20	5.88	0.106	17.77	1	17.77	4.00	2.39	1	8.10	6	19.40	
22	7	10.1	37.86	0.27	6.85	0.1161	24.59	1	24.59	4.00	4.04	1	10.10	10	40.82	
23	8	15.4	41.70	0.35	7.83	0.1262	30.32	1	30.32	4.00	5.98	1	15.40	19	92.17	
24	9	15.4	45.31	0.44	8.80	0.1363	35.21	1	35.21	4.00	8.23	1	15.40	22	126.77	
25	10	10.5	48.69	0.55	9.77	0.1464	39.41	1	39.41	4.00	10.79	2	10.50	17	113.27	
26	11	12.1	51.86	0.66	10.74	0.1565	43.08	1	41	4.33	13.46	2	12.10	20	162.86	
27	12	8.1	54.83	0.79	11.71	0.1666	46.30	1	41	4.88	16.27	2	8.10	13	131.78	
28	13	9.7	57.63	0.92	12.69	0.1767	49.16	1	41	5.44	19.35	2	9.70	16	187.67	
29	14	8.5	60.24	1.07	13.66	0.1868	51.70	1	41	6.00	22.69	2	8.50	14	192.89	
30	15	4.9	62.70	1.23	14.63	0.1969	53.98	2	53.98	4.00	28.32	2	9.80	21	277.52	
31	16	0	0.00	0.00	0.00	0	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
32	17	0.4	67.17	1.58	16.57	0.2171	57.91	2	57.91	4.00	37.58	2	0.80	2	30.07	
33	18	0	0.00	0.00	0.00	0	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
34	19	0	0.00	0.00	0.00	0	0.00	0	0	0.00	0.00	0	0.00	0	0.00	
35	Total	152.2						ave mer tree cf					109	158.6	1375	

**108.5 logs/acre or 1.303 truckloads/acre**

# Biomass Resource

14	Define submerchantable (&biomass) trees and corresponding bone dry weight (Brown, Snell, Bunnell 1977)													
15						Dry (1.)		(2.)		Bone dry				
16					Butt	Wood	Bark	Crown	Whole	Gross	Dirty	Dirty	Clean	
17	DBH	Log	Cut	Ht	end dib	Bole Wt	Wt	Wt	Tree	W.Tree	BD chips	green	BD chips	
18	(in)	Test	TPA	(ft)	(in)	(lbs/tree)	(lbs/tree)	(lbs/tree)	(lbs/tree)	(lbs/acre)	(tons)	(tons)	(tons)	
19	1	FALSE	12.6	8.88	1.02	0.63	0.13	1.27	2.03	25.64	0.40	0.40	0.00	
20	2	FALSE	6.9	14.51	2.00	3.94	0.82	5.58	10.33	71.30	1.11	1.11	0.00	
21	3	FALSE	6.9	19.80	2.97	11.87	2.48	13.26	27.61	190.49	2.97	2.97	0.00	
22	4	FALSE	10.9	24.76	3.94	26.15	5.47	24.51	56.13	611.81	9.55	9.55	0.00	
23	5	FALSE	11.7	29.41	4.91	48.28	10.09	39.49	97.86	1144.91	17.88	17.88	0.00	
24	6	TRUE	0	0.00	5.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
25	7	TRUE	0	0.00	6.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
26	8	TRUE	0	0.00	7.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
27	9	TRUE	0	0.00	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
28	10	TRUE	0	0.00	9.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
29	11	TRUE	0	0.00	10.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
30	12	TRUE	0	0.00	11.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
31	13	TRUE	0	0.00	12.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
32	14	TRUE	0	0.00	13.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
33	15	TRUE	0	0.00	14.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
34	16	FALSE	0	0.00	15.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
35	17	TRUE	0	0.00	16.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
36	18	FALSE	0	0.00	17.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
37	19	FALSE	0	0.00	18.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
38	Total		49							2044.15	31.92		0.00	
39	Average dbh of submerchantable trees cut						3.39							

# Transportation = f(logs)

20	Log Product 1	1		
21	Description	pallets		
22	One-way distance to mill (miles)	150		
23	Total number of loads for project	37.35		
24	Transportation Costs			
25	Average speed loaded (mph)	60		
26	Back haul average speed (mph)	75		
27	Time to Mill (hr)	2.50		
28	Back haul time (hr)	2.00		
29	Hook time in woods (hr)	0.50		
30	Drop time at mill (hr)	0.50		
31	Product 1 transportation costs	\$10,116.38	\$/load	\$270.88

6-in SED, 16-ft

20	Log Product 1	1		
21	Description	pallets		
22	One-way distance to mill (miles)	150		
23	Total number of loads for project	52.76		
24	Transportation Costs			
25	Average speed loaded (mph)	60		
26	Back haul average speed (mph)	75		
27	Time to Mill (hr)	2.50		
28	Back haul time (hr)	2.00		
29	Hook time in woods (hr)	0.50		
30	Drop time at mill (hr)	0.50		
31	Product 1 transportation costs	\$14,290.03	\$/load	\$270.88

4-in SED, 12-ft

# Define Harvest System

65	<b>Grapple Skidding</b>	TRUE
66	Logs or Trees	Logs
67	Machine 1	
68	Engine rating (hp): valid for 115-260hp	129
69	Number of years owned	5
70	Wheel or Track	Wheel
71	Machine 2	
72	Engine rating (hp): valid for 105-260hp	160
73	Number of years owned	4
74	Wheel or Track	Wheel
75	<b>Delimber</b>	FALSE
76	Machine 1	
77	Engine rating (hp): valid to 225hp	
78	Number of years owned	
79	Machine 2	
80	Engine rating (hp)	
81	Number of years owned	
82	<b>Loader</b>	TRUE
83	Machine 1	
84	Engine rating (hp)	130
	Number of years owned	4
	Wheel, Track, or Truck	Wheel
	Machine 2	
	Engine rating (hp)	
	Number of years owned	
	Wheel, Track, or Truck	
	<b>Tracked Dozer</b>	TRUE
	Machine 1	
	Engine rating (hp): valid for 80-130hp	130
	Blade capacity (yd <sup>3</sup> )	5.78

Input Details

## Sources

- Northern Arizona studies
- Various FERIC studies
- Drews et al. 2001
- Hartsough et al. 1997, 1998, 2000
- McNeel & Rutherford 1994
- Thompson 2003

# Treatment Costs

21	<b>Direct Costs due to Harvesting Merchantable</b>	
22	<i>Hand Felling</i>	1
23	Subcontract to independent crews?	1
24	Number of sawyers, n	6
25	Delimiting and bucking?	1
26	Prod time for n sawyers (hrs/ac)	0.61
27	Sawyer utilization	57.63%
28	Total time for n sawyers (hrs/ac)	1.06
29	Total project time for n sawyers (hours)	39.06
30	Costs of own crew	
31	Sawyer labor costs for project	\$0.00
32	Sawyer equipment costs for project	\$0.00
33	Total costs of own crew	\$0.00
34	Subcontractor costs	
35	Total loads/project	52.76
36	\$/load	\$125.00
37	Subcontractor costs	\$6,594.38
38	Felling Operation Costs	\$6,594.38
39	<i>CTL Harvesting</i>	0
40	Processing Time per machine (hrs/acre)	0.00
41	Harvester Efficiency	0.80
42	Total for processing per machine (hrs/acre)	0.00
	Number of machines, n	0
	Total project time for n processor (hours)	0.00
	Project Harvesting Costs	
	Labor costs	\$0.00
	Equipment costs	
	Operational costs	\$0.00
	Controlling project ownership time (hrs)	0.00
	Ownership costs	\$0.00
	CTL Costs	\$0.00
	<i>Whole-Tree Harvesting by Feller-Buncher</i>	0
	Processing Time per machine (hrs/acre)	0.00
54	Harvester Efficiency	0.65
55		0.00

## User Inputs

- Number of machines
- Equipment set
- Number of operators
- Delimiting
- Type of activities preformed (e.g., slash piling, roadside)

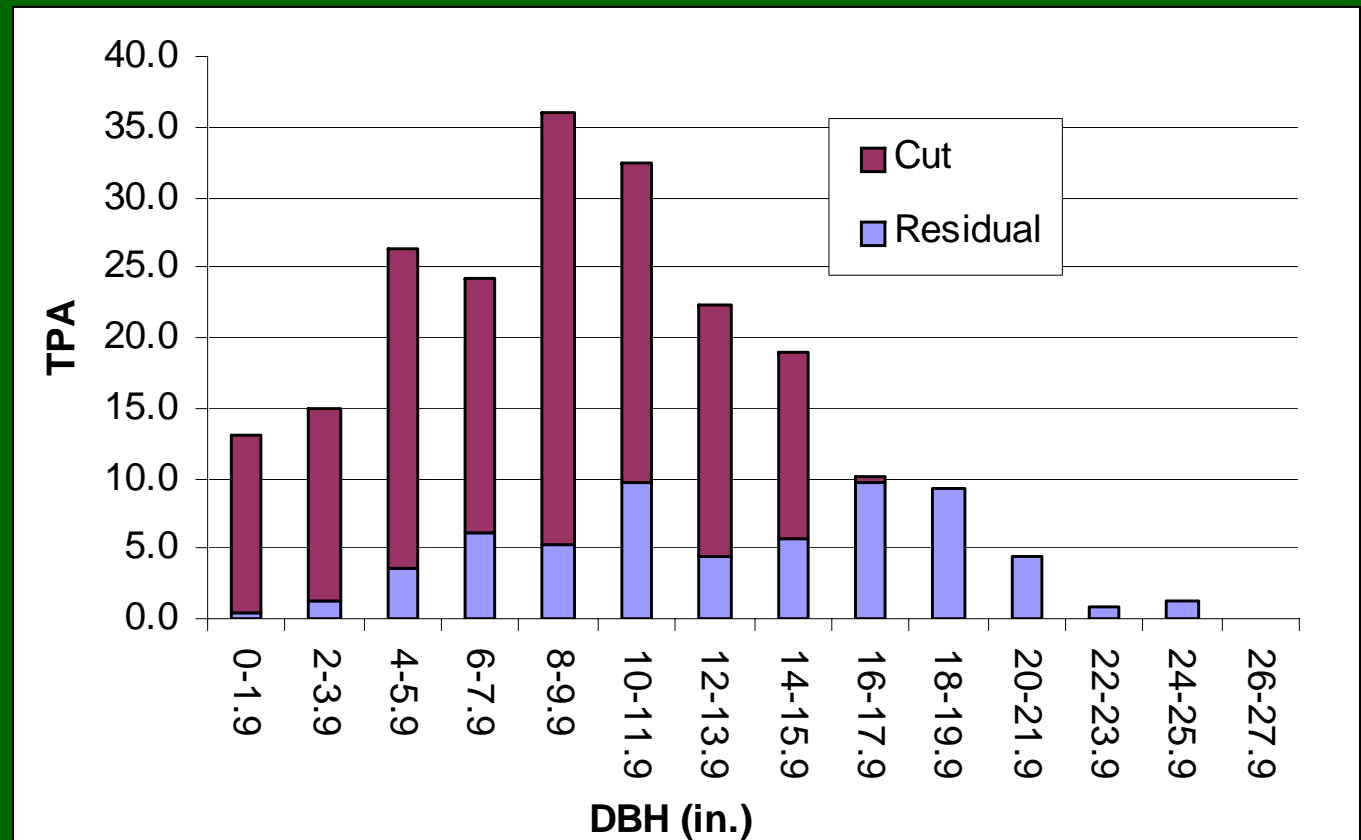
# Production Rates

87	<b>Feller-Buncher for Merchantable &amp; Sub Merch</b>									
88	For F/B: Examined Hartsough et al (2001), Thompson (2003), Hartsough et al (1998), and Ha									
89	as the base equation but modified by Hartsough et al (1997) to estimate # trees/cycle and Ha									
90	The #trees/cylce eqn, however, was scaled to Thompson's average #tree/cycle per average tre									
91	<i>Merchantable Trees</i>									
92					Tree vol	Tree vol	F/B Production			
93	DBH	Log	BA	Cut	to top	to tip	Rate	Rate		
94	(in)	Test	(ft^2)	TPA	cf/tree	cf/tree	#rees	F/B	F/B	
95	1	FALSE	0.01	0	0.00	0.00	0.00	27.9939	0	
96	2	FALSE	0.02	0	0.00	0.00	0.00	27.9155	0	
97	3	FALSE	0.05	0	0.00	0.00	0.00	27.785	0	
98	4	FALSE	0.09	0	0.00	0.00	0.00	27.6022	0	
99	5	FALSE	0.14	0	1.03	0.00	0.00	27.3672	0	
100	6	TRUE	0.20	8.1	2.39	3.09	2.64	19.1852	155.4	
101	7	TRUE	0.27	10.1	4.04	4.62	2.57	19.07	192.61	
102	8	TRUE	0.35	15.4	5.98	6.48	2.49	18.8961	291	
103	9	TRUE	0.44	15.4	8.23	8.67	2.42	18.6657	287.45	
104	10	TRUE	0.55	10.5	10.79	11.19	2.35	18.38	192.99	
105	11	TRUE	0.66	12.1	13.66	14.04	2.28	18.0399	218.28	
106	12	TRUE	0.79	8.1	16.84	17.21	2.21	17.6459	142.93	
107	13	TRUE	0.92	9.7	20.35	20.72	2.14	17.1985	166.83	
108	14	TRUE	1.07	8.5	24.17	24.54	2.08	16.6978	141.93	
109	15	TRUE	1.23	4.9	28.32	28.70	2.01	16.1441	79.106	
110	16	FALSE	0.00	0	0.00	0.00	0.00	28.02	0	
111	17	TRUE	1.58	0.4	37.58	37.99	1.87	14.8781	5.9512	
112	18	FALSE	0.00	0	0.00	0.00	0.00	28.02	0	
113	19	FALSE	0.00	0	0.00	0.00	0.00	28.02	0	

# Coconino National Forest – Flagstaff, AZ

## A-1 Mountain, Unit #273

Cutting Activity	
DBH Class (in)	Cut TPA
1	12.6
2	6.9
3	6.9
4	10.9
5	11.7
6	8.1
7	10.1
8	15.4
9	15.4
10	10.5
11	12.1
12	8.1
13	9.7
14	8.5
15	4.9
16	0.0
17	0.4
18	0.0
19	0.0



Condition Class 3



# Existing Market: Pallet Lumber

## User Input Market Specifications

Description	pallets
Log small end dib (in)	4
Log large end dib (in)	
Minimum log length shipped (ft)	12
Maximum log length shipped (ft)	41
One-way distance to mill (miles)	150
Average speed to mill (mph)	60
Estimated log %mc at shipping	116.00%
Delivered Price/Load or	
Delivered Price/Green Ton or	\$28.00
Delivered Price/MBF	

# Cost-to-Revenue Summary

Microsoft Excel - Unit273April.xls

File Edit View Insert Format Tools Data Window Help

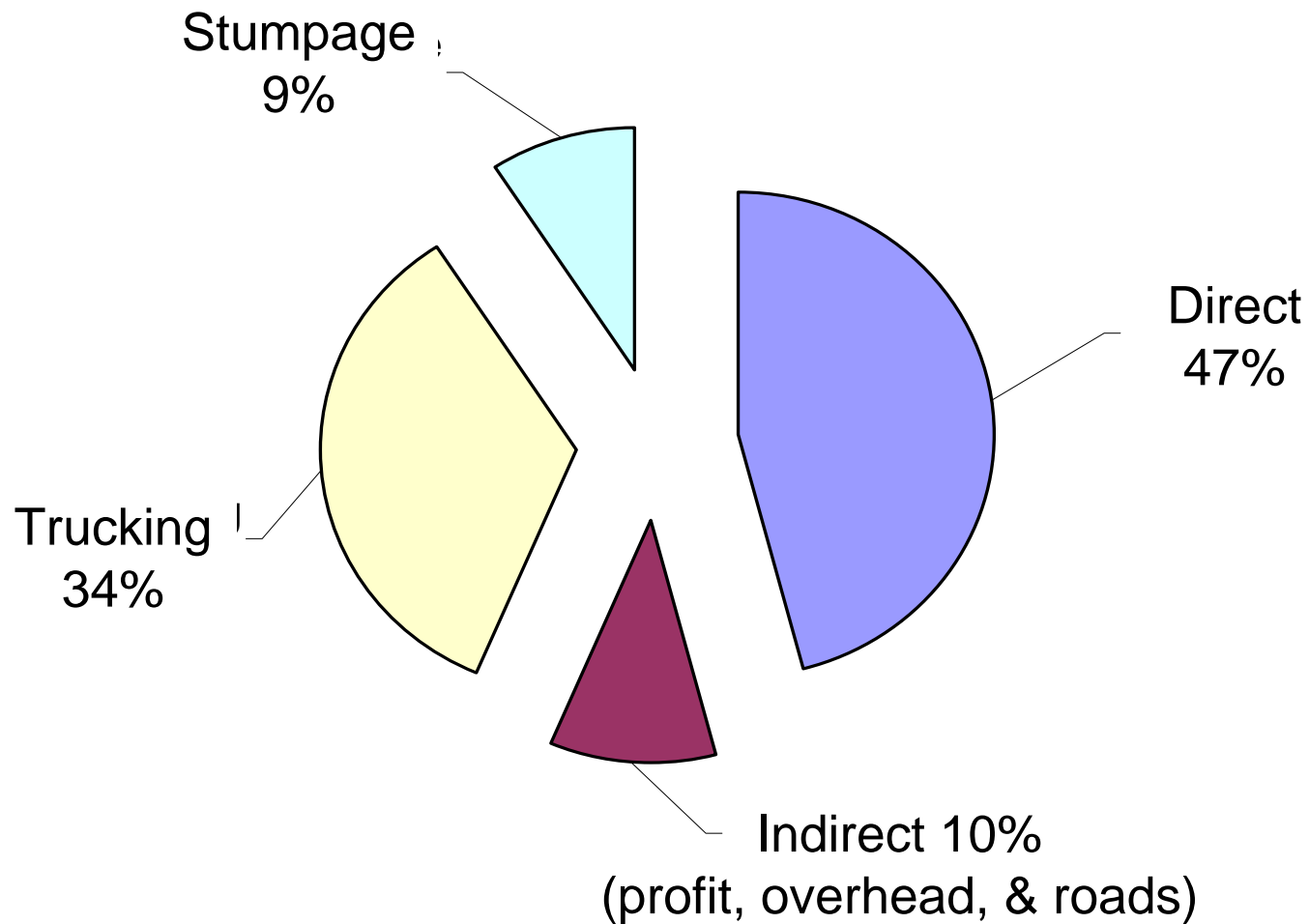
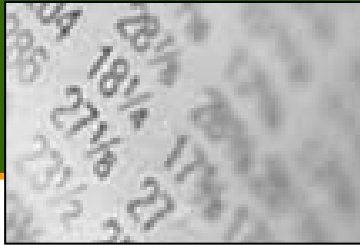
L83 =

	A	B	C
53	<b>Cost Summary</b>	<b>Project Totals</b>	<b>\$/acre</b>
54	Direct Treatment Costs		
55	Mobilization	\$1,017.17	\$27.49
56	Merchantable Direct Costs	\$14,400.44	<b>\$389.20</b>
57	Sub-merchantable Direct Costs	\$3,706.01	\$100.16
58	Chipping & Debarking Direct Costs	\$0.00	\$0.00
	Direct	\$19,123.62	\$516.85
	Indirect	\$4,325.76	<b>\$116.91</b>
	Trucking	\$14,290.03	\$386.22
	Stumpage	\$3,872.16	\$104.65
	<b>Total Cost for Project</b>	<b>\$41,611.58</b>	<b>\$1,124.64</b>
64			
65	<b>Revenue Summary</b>		
66	Service contract	\$13,727.00	<b>\$371.00</b>
67	Roads	\$2,063.00	\$55.76
68			\$0.00
69	Biomass	\$0.00	\$0.00
70	Log Market 1	\$38,405.68	<b>\$1,037.99</b>
71	Log Market 2	\$0.00	\$0.00
72	Log Market 3	\$0.00	\$0.00
73	<b>Total Revenue for Project</b>	<b>\$54,195.68</b>	<b>\$1,464.75</b>
74			

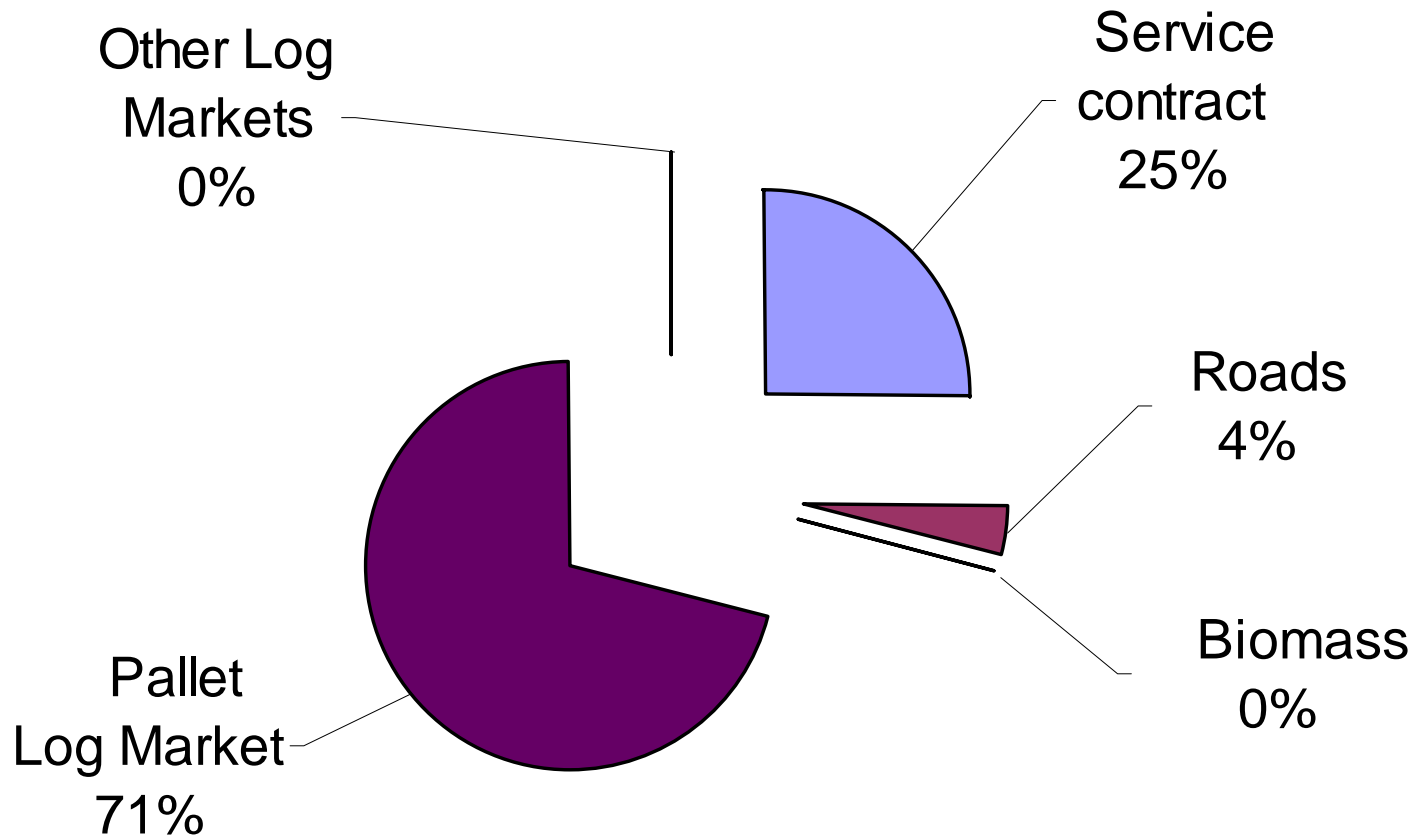
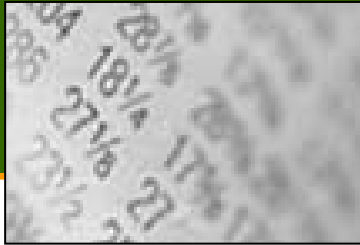
- Profit
- Overhead
- Roads

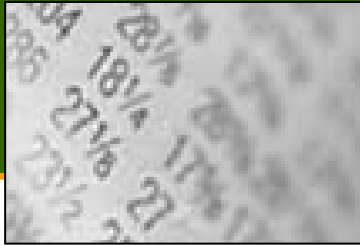
- Purchase price
- Depreciation
- Reinvestment cost
- Interest
- Tax and Insurance
- O&M
- Labor

# Implementation Cost Summary



# Revenue Summary





# Modeling is Estimating

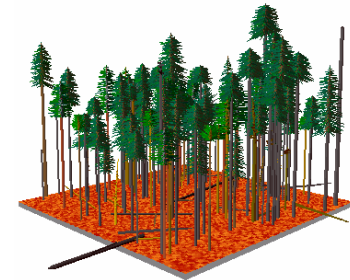
“Remember that estimating is not an exact science. Experience, judgment, and care should enable an estimator to prepare an estimate that will reasonably approximate the ultimate costs of the project.”

**Source:** Peurifoy, R.L. and G.D. Oberlender. 2002. Estimating Construction Costs, 5<sup>th</sup> Ed. McGraw-Hill. New York, NY.



## What's Next – Model Needs

- Biomass related activities, costs, and revenues
- Miscellaneous activities
  - Taper equations for non-Coconino ponderosa pine
  - Road costs
  - Machine piling productivity
- User Interface
  - Gathering input from potential users
  - Adjust assumptions and set user-defaults
  - Define needed output





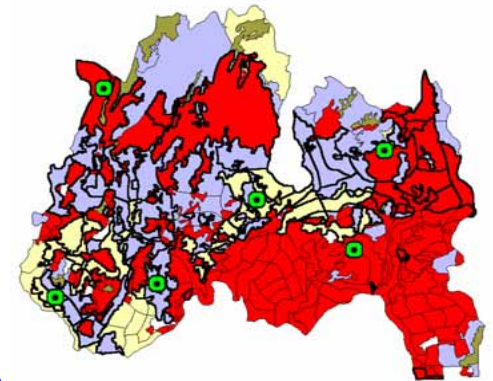
## What's Next – Outreach

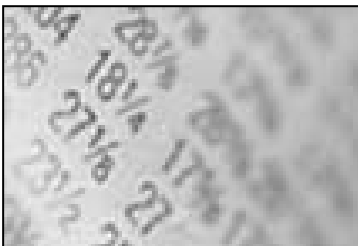
- Model refinement and validation
  - Working with USFS WO, RO, SOs, and Districts
  - Adjust model based on contractor input
  - Develop a field guide for planning and appraisal
- Technology transfer
  - Field demonstrations and workshops
    - Field workshops (Fall '04 – Spring '05)
    - Finalize field guide and develop CD-ROM
  - One-on-one contractor training and model validation
  - Regional and national presentations



# Future Applications

- Sensitivity studies
  - Assessment of timber cruise data, equipment sets
  - Comparison to other model estimators
- Expanded applications
  - Expansion of use for appraisal and contract evaluation
  - Use for non-ponderosa pine species and regions (taper equations required)
  - Environmental policy (diameter cap limits, WUI cost projections, economic subsidies)





## For more information contact:

Dennis R. Becker  
USDA Forest Service  
PNW Research Station  
2500 S. Pine Knoll Drive  
Flagstaff, AZ 86001  
PH: (928) 556-2159  
drbecker@fs.fed.us

(<http://www.fs.fed.us/pnw/sev/esp/ESP-JFS.htm>)

