

Extending BioSum to optimize multi-decade forest restoration and evaluate biochar facility feasibility in the Upper Klamath Basin



Jeremy S. Fried¹, Joshua Petitmermet², John Sessions³

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¹ USDA FS PNW FIA

² Mendocino Redwood Co.

³ Oregon State University



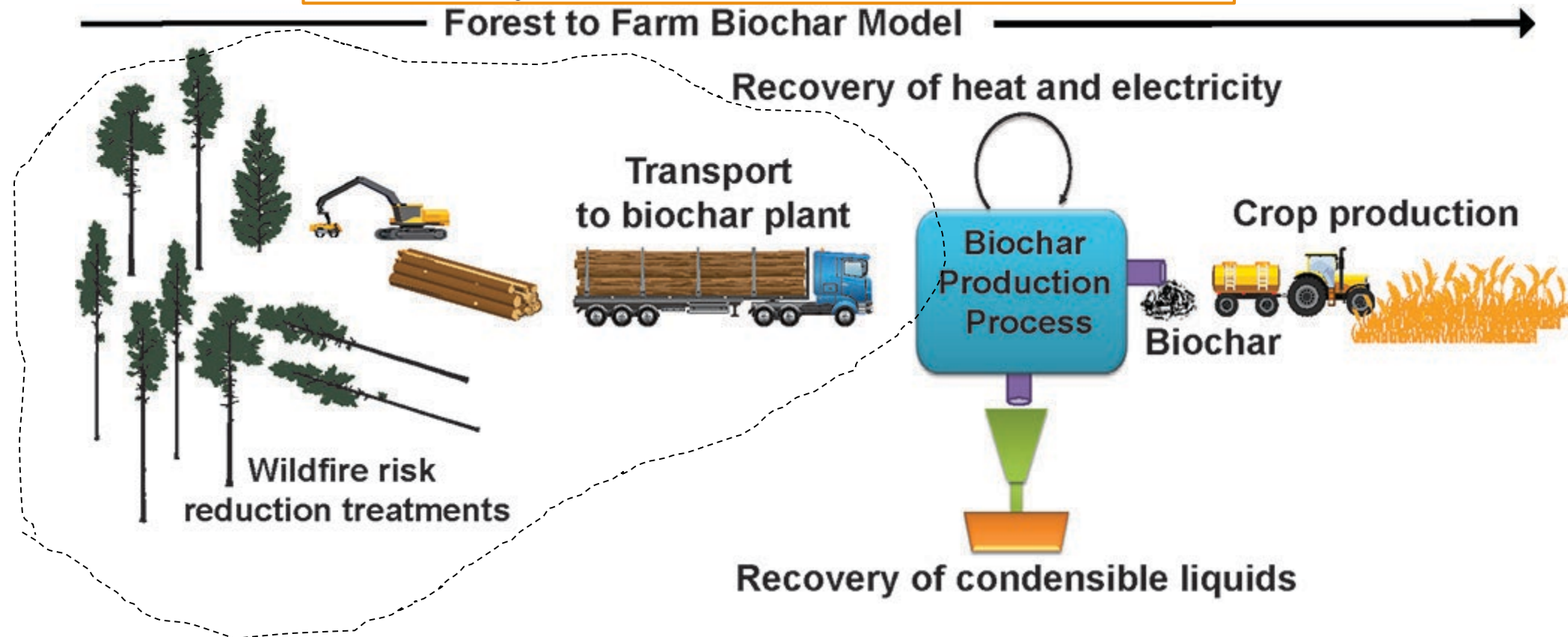
Opportunities for Biochar Production to Reduce Forest Wildfire Hazard, Sequester Carbon, and Increase Agricultural Productivity of Dryland Soils



Oregon State University

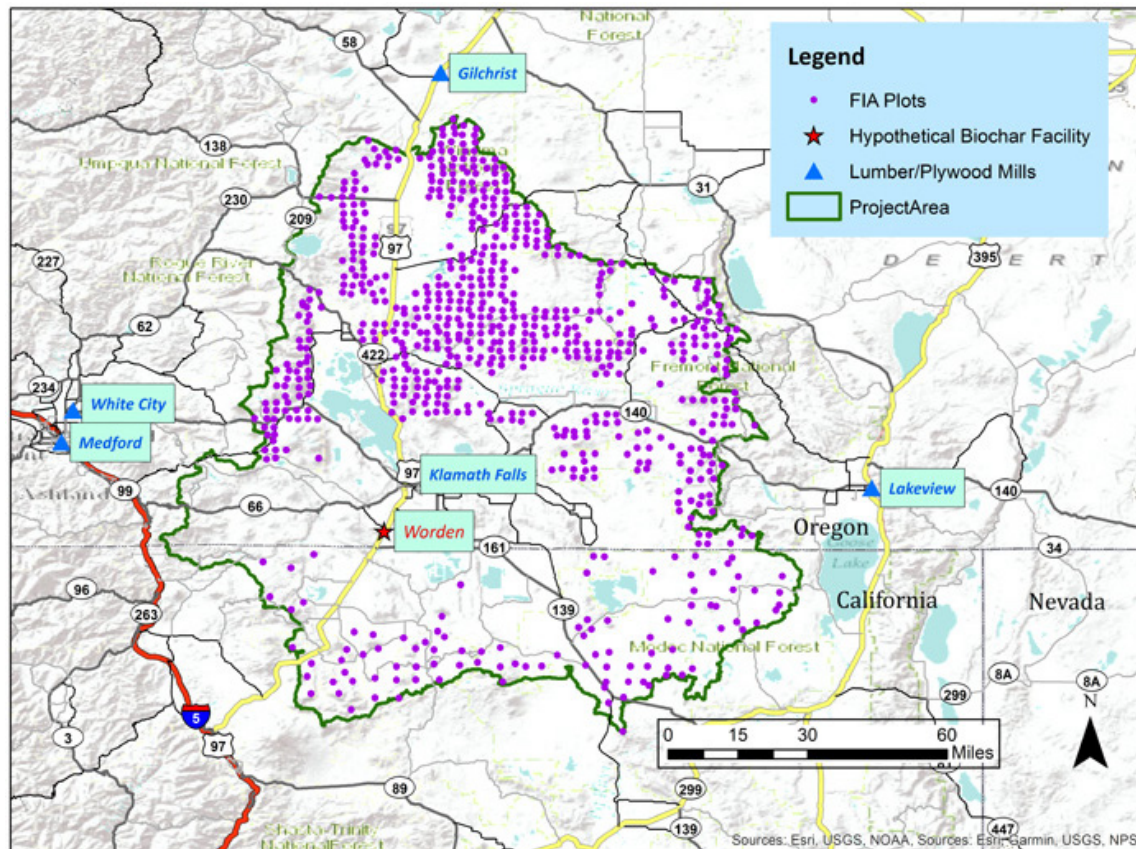
Institute for Working Forest Landscapes

Forest to Farm Biochar Model

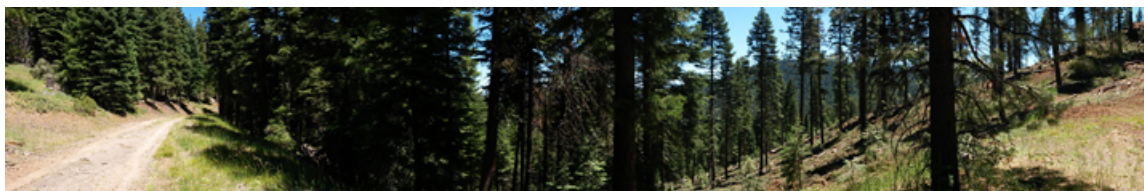


Relied on BioSum + Customization to characterize the Biochar feedstock

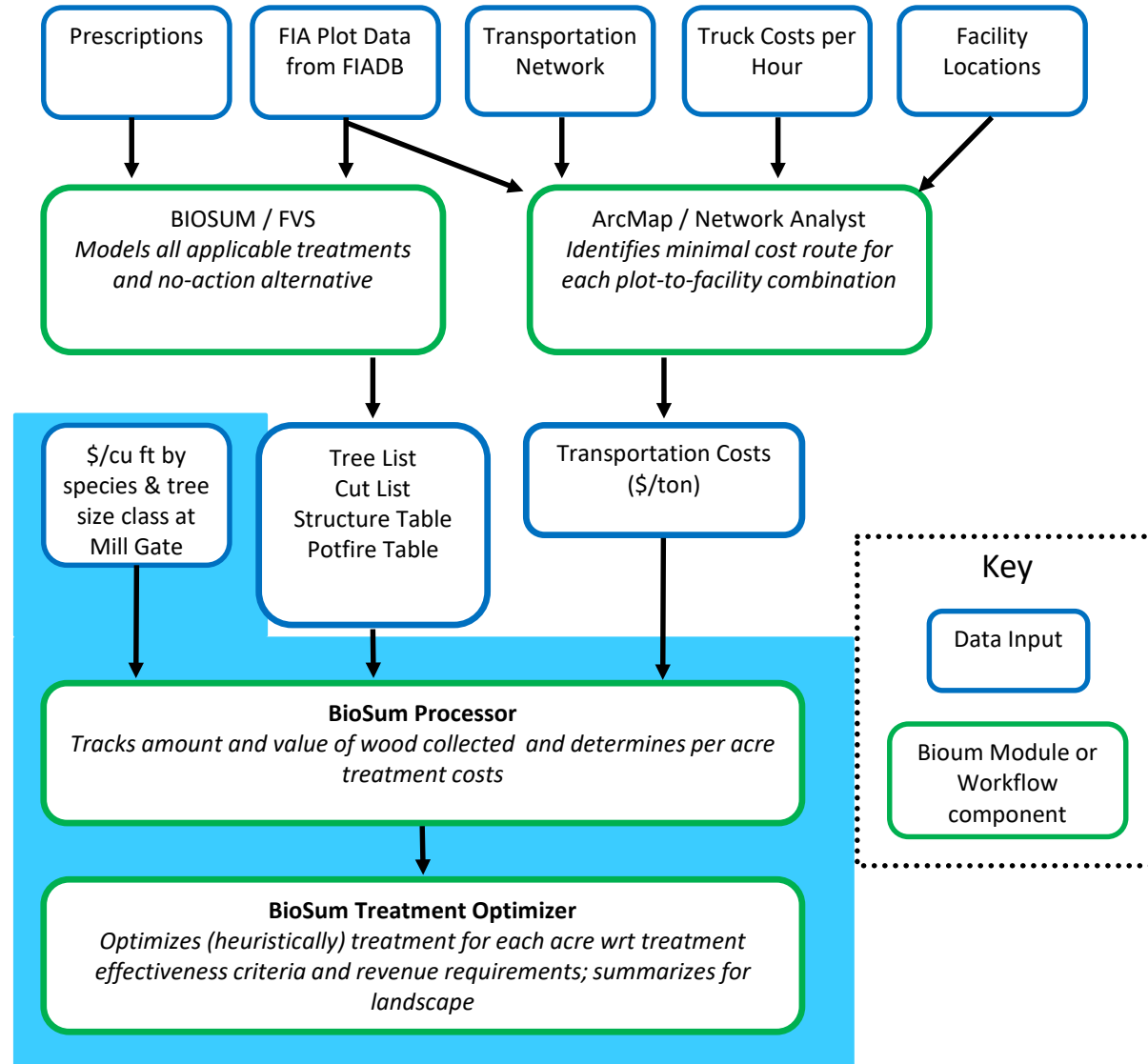
Upper Klamath Basin: Biochar feedstock analysis



- 730 plots on 1.9 million NFS acres
- Modeled with BioSum, customized via publicly posted Python scripts, to merchandise logs and optimize harvest scheduling with even flow and break-even requirements



Standard BioSum version 5.8.7



Advantages

- Proven, automated workflow
- Easy to change problem definition, assumptions & rerun
- Retains all intermediate calcs

Limitations

- “Biomass” def’n hard coded as all non-merch, including tops, limbs
- Biochar: bolewood to a four inch DIB top, with a minimum length of eight feet, so typically a portion of top, or whole bole of non-commercial species
- No harvest scheduling component

BioSum Database Module (FIADB loader)

Database: Add Plot Data

Plot Data Input

FIADB Microsoft Access Database File Input

MSAccess File

Plot Data: Population Evaluation:

Condition Data: Population Estimation Unit:

Tree Data: Population Stratum:

Tree Regional Biomass Data: Population Plot Stratum Assignment:

Site Tree:

Database: Add Plot Data

Plot Data Input

Select FIADB Inventory Evaluation

EvalId	R...	StateCd	Location_Nm	Eval_Descr	Report Year	Notes
61000	26	6	California ...	CALIFORNIA 2010: 2001-2010: ALL AREA	2001,2002,2003,2004,2005,2006,2007,2008,2009,2010 ...	
61001	26	6	California ...	CALIFORNIA 2010: 2001-2010: CURRENT AREA, CURRENT VOLUME, DWM...	2001,2002,2003,2004,2005,2006,2007,2008,2009,2010 ...	
61500	26	6	California ...	CALIFORNIA 2015: 2004-2015: ALL AREA	2004,2005,2006,2007,2008,2009,2010,2011,2012,2013,2...	
61501	26	6	California ...	CALIFORNIA 2015: 2004-2015: CURRENT AREA, CURRENT VOLUME	2004,2005,2006,2007,2008,2009,2010,2011,2012,2013,2...	
61503	26	6	California ...	CALIFORNIA 2015: 2001-2005 to 2011-2015: AREA CHANGE, GROWTH, RE...	2011,2012,2013,2014,2015	
61507	26	6	California ...	CALIFORNIA 2015: 2011-2015: DWM	2011,2012,2013,2014,2015	
61600	26	6	California ...	CALIFORNIA 2016: 2007-2016: ALL AREA	2007,2008,2009,2010,2011,2012,2013,2014,2015,2016 ...	
61601	26	6	California ...	CALIFORNIA 2016: 2005-2016: CURRENT AREA, CURRENT VOLUME	2005,2006,2007,2008,2009,2010,2011,2012,2013,2014,2...	
61603	26	6	California ...	CALIFORNIA 2016: 2001-2005 to 2011-2016: AREA CHANGE, GROWTH, RE...	2011,2012,2013,2014,2015,2016	
61607	26	6	California ...	CALIFORNIA 2016: 2011-2016: DWM	2011,2012,2013,2014,2015,2016	
69401	26	6	California ...	CALIFORNIA 1994, AREA, PERIODIC, no NFS	1994	

Add MS Access Pop Table Data

ppsa table

Overall Progress

Database: Add Plot Data

Plot Data Input

Filter Options

Input All Plots

Filter Plots By Menu Selection (State, County, And Plot)

Filter By File (Text File Containing Plot_CN numbers)

Forested Non Forested

Use Down Woody Materials Data

Use Growth, Removal, Mortality Data

When a forested condition has a condition proportion less than percent, condition status will be changed from forested to nonsampled.

Calculate Adjustment Factors

Drop Work Tables

Overall Progress

BioSum FVS Module

FVS: Create FVS Input

Create FVS Input

FVS: Process FVS Output

Join And Append FVS Out Data

FVS Output Directory:

	FVS Variant	RxPackage	Cycle1Rx	Cycle2Rx	Cycle3Rx	Cycle4Rx
<input checked="" type="checkbox"/>	BM	009	104	104	104	104
<input type="checkbox"/>	BM	010	105	105	105	105
<input type="checkbox"/>	BM	012	107	107	107	107
<input type="checkbox"/>	BM	024	205	205	205	205
<input type="checkbox"/>	BM	999	999	999	999	999
<input type="checkbox"/>	EC	009	104	104	104	104
<input type="checkbox"/>	EC	010	105	105	105	105
<input type="checkbox"/>	EC	012	107	107	107	107
<input type="checkbox"/>	EC	024	205	205	205	205
<input type="checkbox"/>	EC	999	999	999	999	999
<input type="checkbox"/>	IE	009	104	104	104	104

Tasks To Complete For Each Item: a=Append

Step 1 - Define PRE/POST Table SeqNum

FVS: Create FVS Input

FVS Output PRE-POST Sequence Number Definition

Id	TableName	Type	Packages
1	FVS_SUMMARY	DEFAULT	NA
2	FVS_CUTLIST	DEFAULT	NA
3	FVS_STRCLASS	DEFAULT	NA
4	FVS_POTFIRE	DEFAULT	NA
5	FVS_CARBOON	CUSTOM	009
6	FVS_COMPUTE	CUSTOM	009

ID: 4 Table: FVS_POTFIRE Type: DEFAULT

PRE-TREATMENT SEQNUM **POST-TREATMENT SEQNUM**

Cycle 1 Base Year

Cycle 2

Cycle 3

Cycle 4

Default SeqNum Options:

SeqNum Assignments: Use FVS_SUMMARY Use FVS_POTFIRE

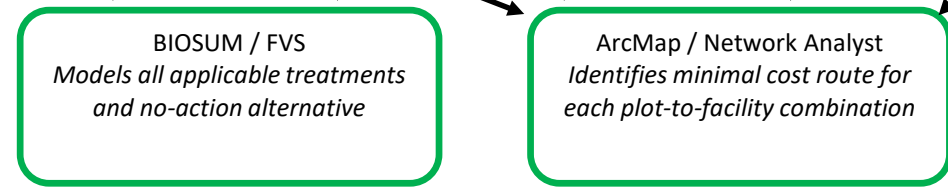
Packages:

Description: Define DEFAULT PRE-POST sequence number pattern of cycles 1,2,3 and 4 for this table only.

Growth Removal Mortality

Use GRM calibration data if available

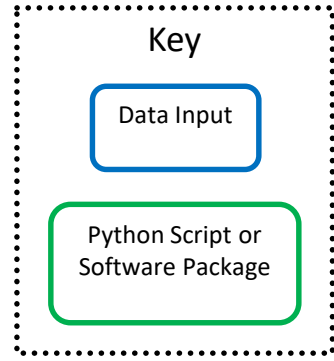
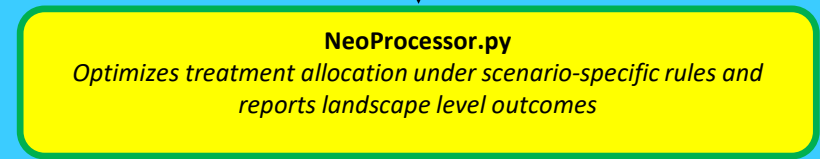
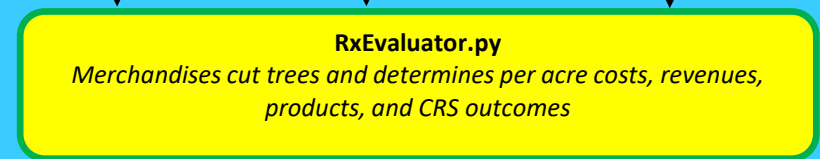
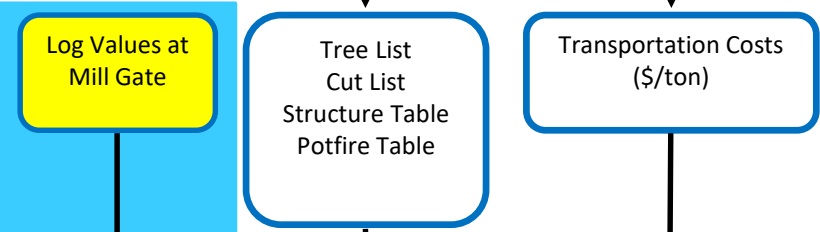
BioSum +(python) RxEvaluator/NeoProcessor



Maximize Area-weighted fire resistance @ years 1, 6, 11, 16, 20

Subject to

- Each acre **treated no more than once** and by only 1 treatment
- Treatment area \leq **Treatment Capacity**
- Treated area **doesn't vary by more than 20%** per period
- Treatment **Cost \leq Revenue** from wood sales in period
- Each acre treated or assigned to grow-only



Prescriptions, which vary by stand type & are designed to improve fire resistance, were applied in FVS at year 1, 6, 11, or 16 of a 20 year simulation

1-story
>70% junk

Treatment style	Treatment number	Dominant species	Strata count	Minimum basal area (ft ² per ac)	Residual BA target (ft ² per ac)	DBH "cap" (in.)
Thin from below (TFB)	1	Any or none	1	150	100	10
	2	Any or none	1	150	100	16
	3	Any or none	1	120	75	21
Q-factor (q-f)	4	Any or none	≥ 2	125	75	20
	5	Any or none	≥ 2	110	50	24
Pseudo-clearcut (pcc)	6	PICO	Any	80	N/A	N/A
		JUOC	Any	35	N/A	N/A



- Tethered, CTL
- Limbs → brush mat
- Tops, small trees, and noncommercial species → biochar feedstock

Fire resistance scoring:

Σ subscores \rightarrow Composite Resistance Score¹ of 0-12

Component Score	Canopy Bulk Density (kg/m ³)	Fuel Strata Gap (feet)	Resistant Species as a percent of BA	FOFEM Survival as a % of volume
0	> 0.15	≤ 7	≤ 25	≤ 2
1	0.11 to 0.15	7 to 20	25 to 50	2 to 30
2	0.051 to 0.10	20 to 30	50 to 75	30 to 75
3	≤ 0.05	> 30	75 to 100	> 75

□ CRS calculated at each 5-yr cycle break

□ EXPCURR devolved into 100 ac subunits

□ $Max \sum_{period=1}^5 AreaWt'd CRS$

¹ Jain, Fried and Loreno. Forthcoming in *Forest Science*. Simulating the effectiveness of improvement cuts and commercial thinning to enhance fire resistance in west coast dry mixed conifer forests.

Assumptions for grow-only, burned at landing (BAL), utilized as biochar (UAB) and unconstrained (UNC) scenarios

Scenario label	Feedstock disposition	Annual area	Management Return
		treated (ac.)	Interval (yrs.)
G-O	NA- grow-only	0	NA
MRI-100 BAL	Burned at landing	19,000	100
MRI-100 UAB	Utilized as biochar	19,000	100
MRI-50 BAL	Burned at landing	38,000	50
MRI-50 UAB	Utilized as biochar	38,000	50
MRI-25 BAL	Burned at landing	76,000	25
MRI-25 UAB	Utilized as biochar	76,000	25

Immediate score change relative to grow-only when implemented at year 1

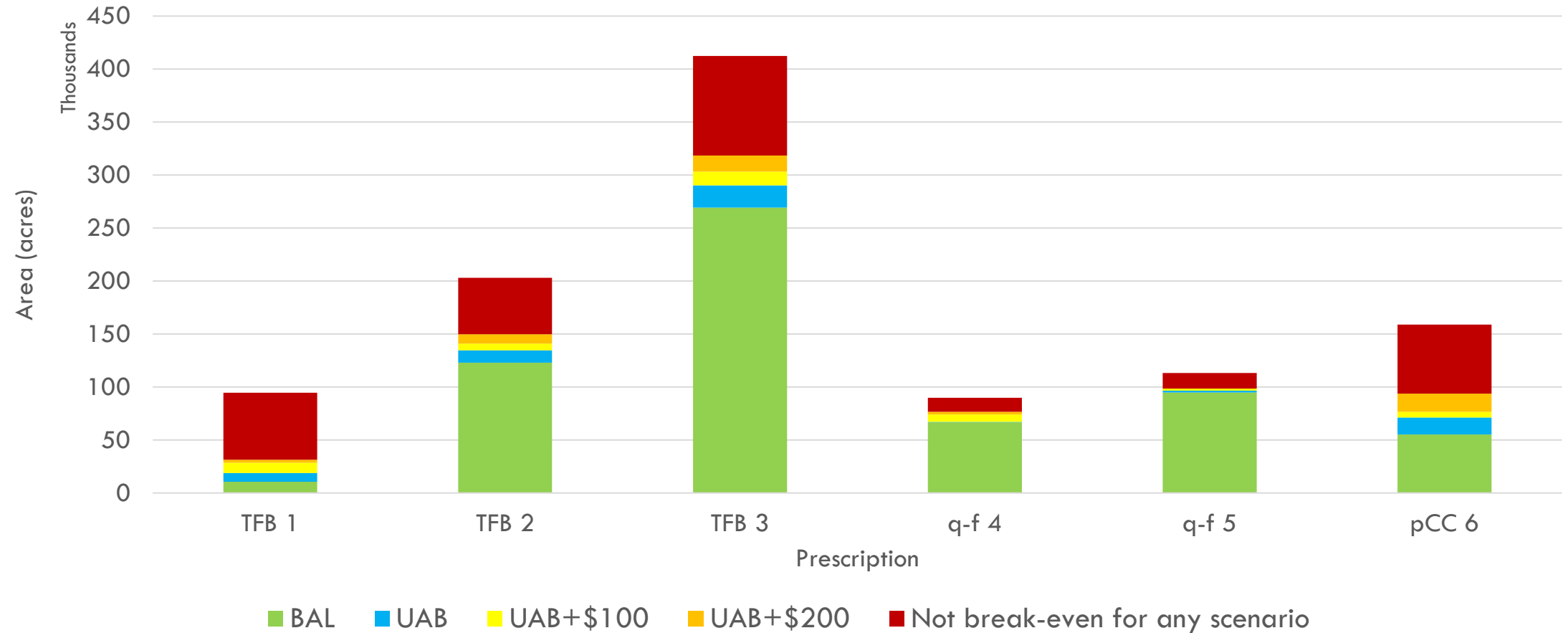
Treatment	Average score change at year 1				
	Sub-score				Composite Resistance Score
	Fuel Strata Gap	Canopy Bulk Density	Resistant Species	Survival	
TFB 1	1.15	0.91	0.17	0.30	2.53
TFB 2	1.04	1.18	0.34	0.43	2.98
TFB 3	0.87	1.19	0.39	0.38	2.83
q-f 4	0.66	1.42	0.25	0.25	2.57
q-f 5	0.70	1.26	0.36	0.24	2.56
q-f 6	0.34	0.73	0.40	1.24	4.81



Area eligible for treatment & frequency with which treatment at yr 16 (4th period) → increase, no change or decrease in CRS

Treatment	Eligible area (thousand acres)	% where CRS increased	% with no change in CRS	% where CRS decreased
TFB 1	129.0	91	9	0
TFB 2	260.1	94	5	1
TFB 3	509.4	91	9	0
q-f 4	177.7	86	14	0
q-f 5	193.4	93	7	0
pCC 6	284.5	98	1	1

Eligible area achieving break-even, with feedstock used as biochar (UAB), by scenario and prescription



Mean CRS by representative year, sum over all 5 years, and sum expressed as a percent of maximum possible CRS

Scenario	Year 1	Year 6	Year 11	Year 16	Year 20	Sum of scores	Pct. of Max
G-O	6.84	6.91	6.98	6.98	7.00	34.64	58%
MRI-100	7.15	7.60	8.03	8.52	8.54	39.83	66%
MRI-50	7.45	8.47	9.38	10.19	10.21	45.69	76%
MRI-25	7.55	8.78	9.61	10.34	10.36	46.65	78%
UNC	9.06	10.02	10.41	10.66	10.67	50.82	85%

The BAL and UAB scenarios produced identical results for a given capacity constraint so only one set of results is reported per MRI.

Mean annual net revenue (million dollars) from sales of wood, less treatment and haul costs, and total present net value over 20-yr simulation

Scenario	Period 1	Period 2	Period 3	Period 4	20-yr PNV ¹
G-O	0	0	0	0	0
MRI-100 BAL	30.9	21.9	18.1	17.6	351.7
MRI-100 UAB	33.1	23.6	20.3	19.7	383.1
MRI-50 BAL	41.5	21.8	24.3	32.1	466.9
MRI-50 UAB	45.6	25.7	28.4	35.9	528.1
MRI-25 BAL	47.6	22.8	27.8	34.8	520.2
MRI-25 UAB	52.2	27.9	31.6	38.7	587.8

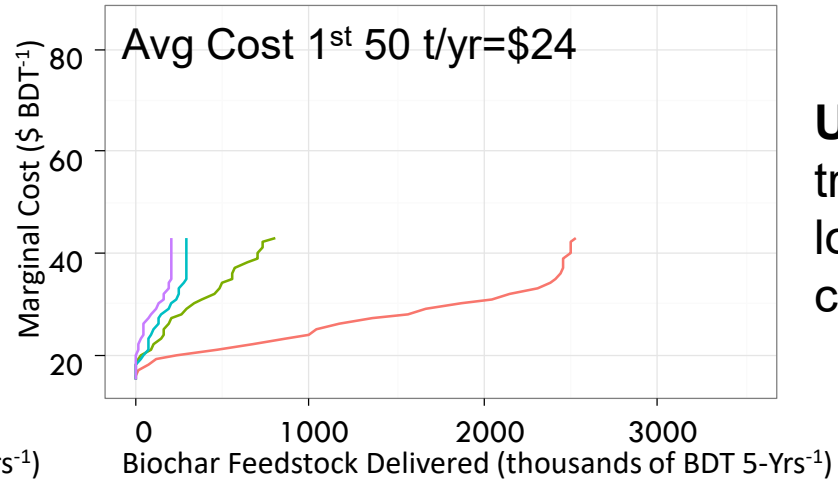
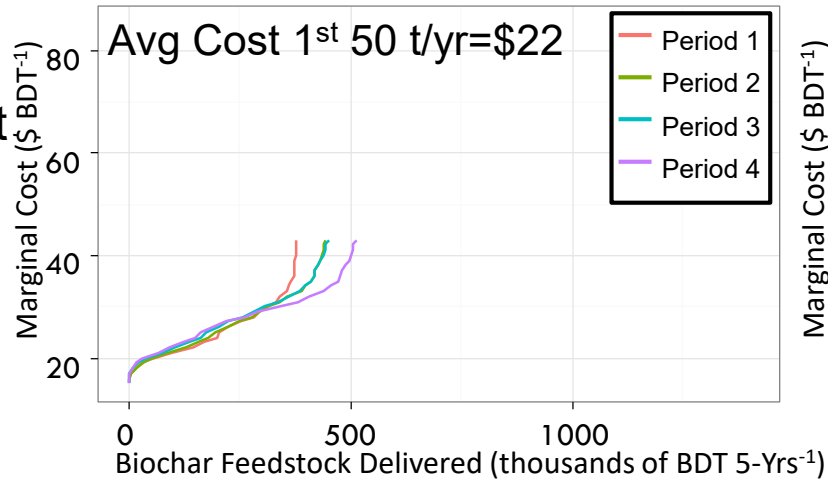
¹ at discount rate of 3%

Annual wood production

Scenario	Period 1	Period 2	Period 3	Period 4	20-yr yield
Sawlogs (thousand BDT)					
MRI-100	334	287	273	286	5,897
MRI-50	522	410	450	530	9,562
MRI-25	583	498	506	576	10,820
UNC	1465	284	160	148	10,291
Biochar feedstock Sawlogs (thousand BDT)					
MRI-100	76	91	91	104	1,810
MRI-50	165	198	188	185	3,687
MRI-25	188	244	186	187	4,025

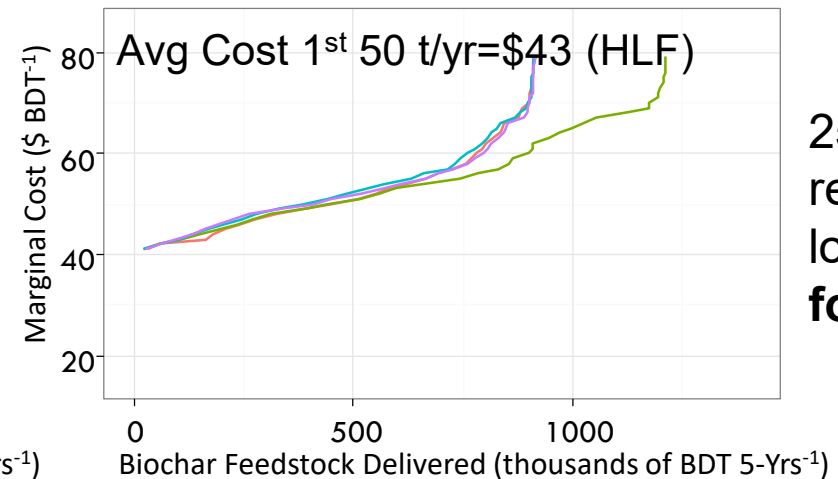
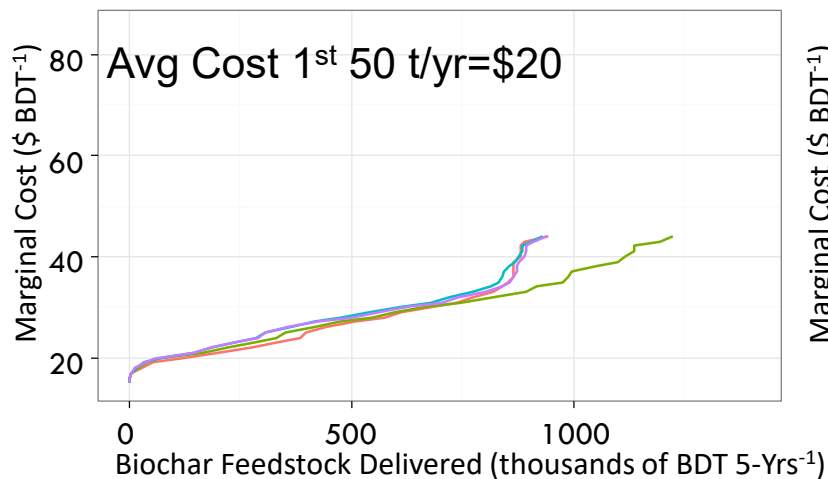
Marginal cost at Worden, per 5-yr period, as a function of biochar feedstock produced from the Upper Klamath

100-yr management return interval; loading and hauling costs only



Unconstrained treatment capacity; loading and hauling costs only

25-yr management return interval; loading and hauling costs only



25-yr management return interval; loading + hauling + **forwarding costs**

Takeaways

- BioSum good for testing Rxs and sifting through management scenarios
- ...and for developing supply curves
- Modular design allows for even greater customization by the motivated
- More info at:
 - ▣ <https://www.forestry.oregonstate.edu/research/biochar>
 - ▣ <http://bioum.info>
 - ▣ Journal of Forestry article (copies available by the door)
- Questions, suggestions??

Questions/comments?

More info at:

<https://www.forestry.oregonstate.edu/research/biochar>

<http://bioum.info>

Mean annual treatment area (thousand acres), by 5-year period

Scenario	Period 1	Period 2	Period 3	Period 4	Total
MRI-100	19	19	19	19	380
MRI-50	38	38	38	38	760
MRI-25	43	50	43	42	886
UNC	109	38	21	14	912

Results for MRI-100 and MRI-50 were identical for BAL and UAB, and nearly so for MRI-25

UNC treated every eligible acre in period 1 to maximize CRS over the 5 time points, deferring mainly those acres not yet eligible (e.g., that were below the basal area trigger)



Average cost (\$/BDT) for 1st 250,000 BDT/5-yr period delivered to hypothetical facility at Worden, OR

	Load-Haul Average Cost				Forward-Load-Haul Average Cost			
	Period				Period			
Scenario	1	2	3	4	1	2	3	4
MRI-100	22.49	23.24	23.59	23.92	45.99	46.49	46.66	47.02
MRI-50	21.02	21.51	21.58	21.68	43.68	44.66	44.63	44.56
MRI-25	20.56	21.23	21.56	21.64	43.69	44.07	44.55	44.46
UNC	20.04	23.56	25.93	28.80	42.32	47.82	51.16	55.96

Note: Hypothetical price paid at facility gate is \$50/BDT

Eligible area and percent of eligible area exceeding break-even (net revenue \geq 0 dollars) by the 4th 5-year cycle

Treatment	Eligible area (thousand acres)	Percent of eligible exceeding break-even	
		Burned at Landing	Used as Biochar
TFB 1	129.0	15	20
TFB 2	264.1	58	63
TFB 3	509.4	67	69
q-f 4	177.7	74	80
q-f 5	193.4	86	89
nCC 6	288.0	38	42