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

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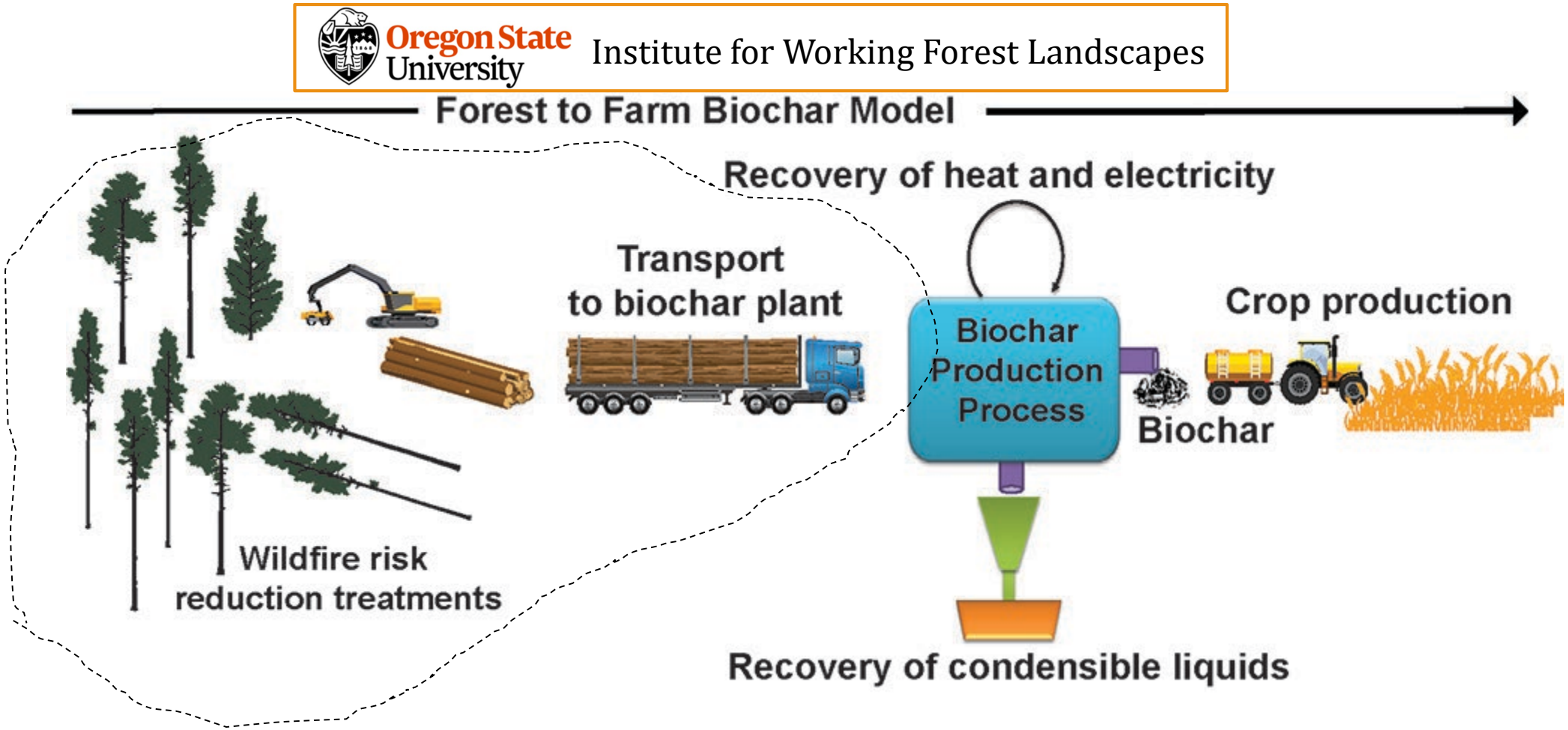
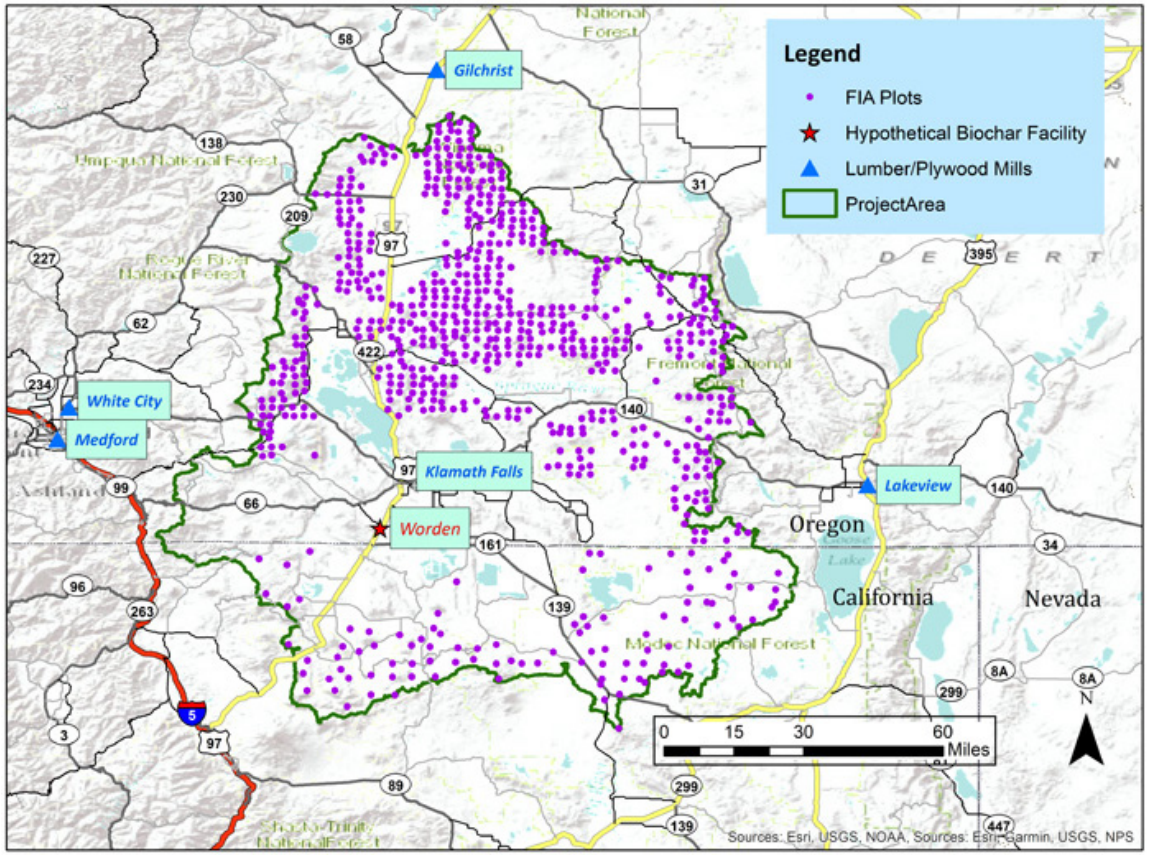
Opportunities for Biochar Production to Reduce Forest Wildfire Hazard, Sequester Carbon, and Increase Agricultural Productivity of Dryland Soils



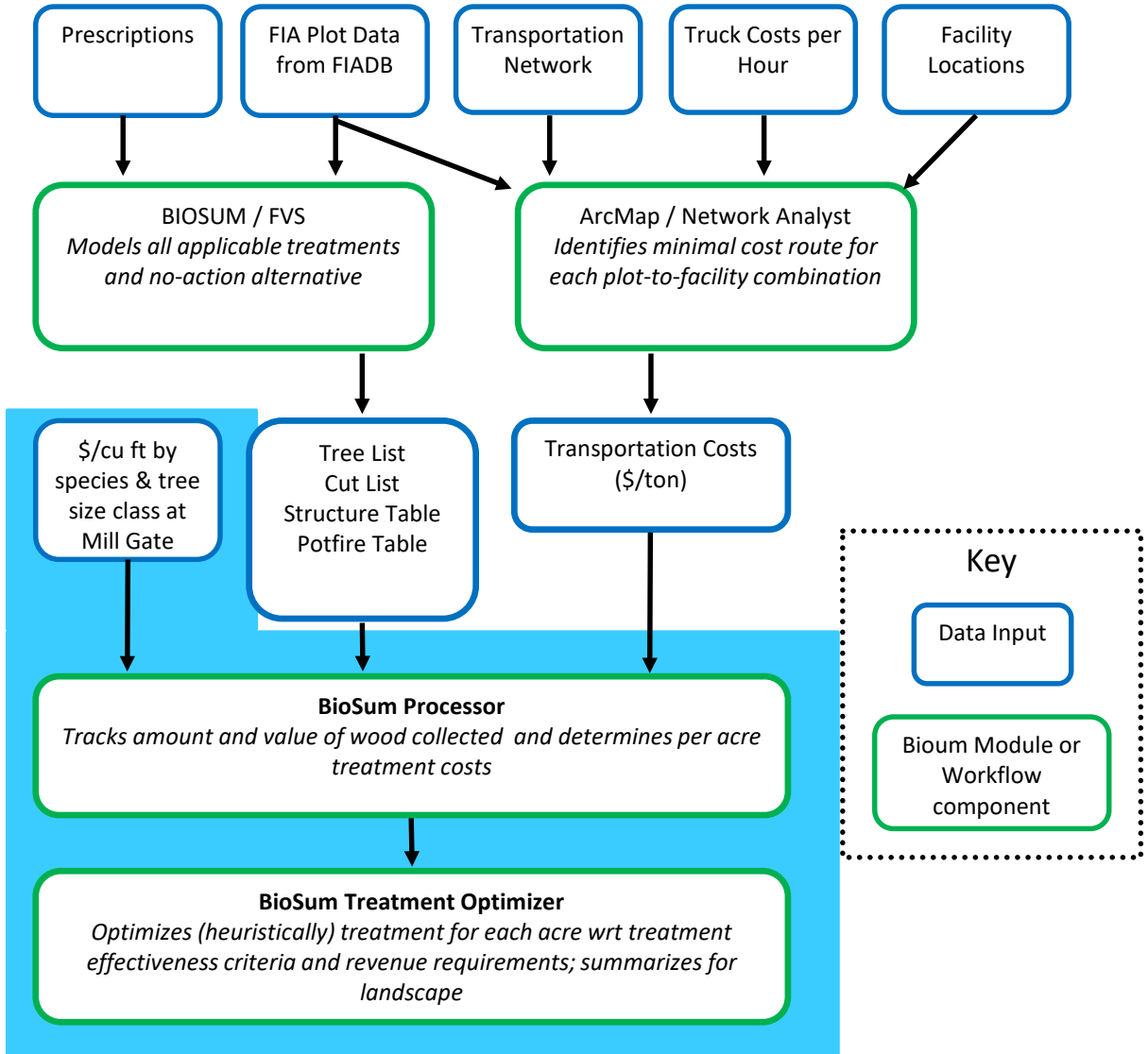
Relied on BioSum + Customization to characterize the Biochar feedstock

Upper Klamath Basin: Biochar feedstock analysis



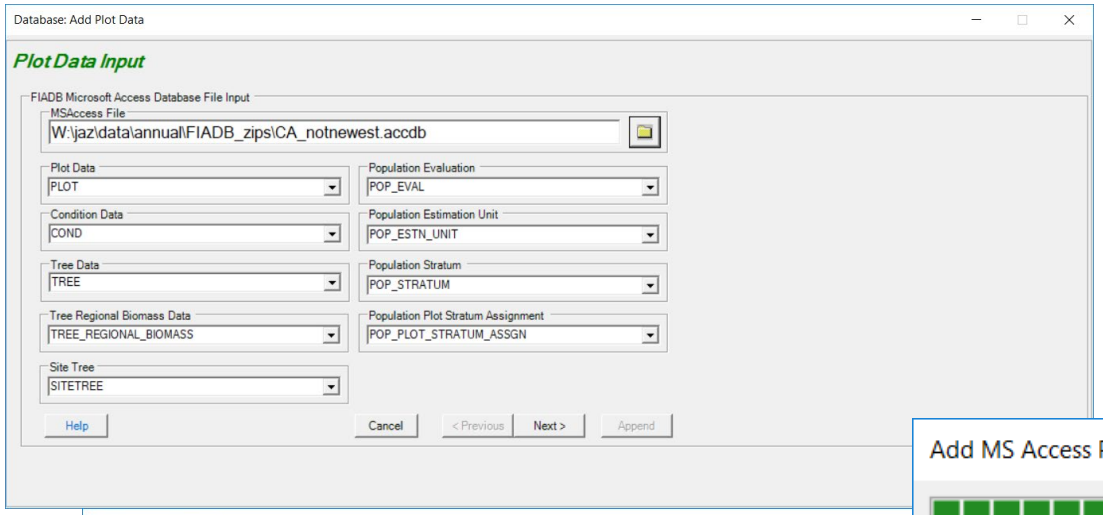
- 730 plots on 1.9 million NFS acres
- Modeled with BioSum, customized via publicly posted Python scripts, to merchandise logs and optimize harvest scheduling with even flow and break-even requirements

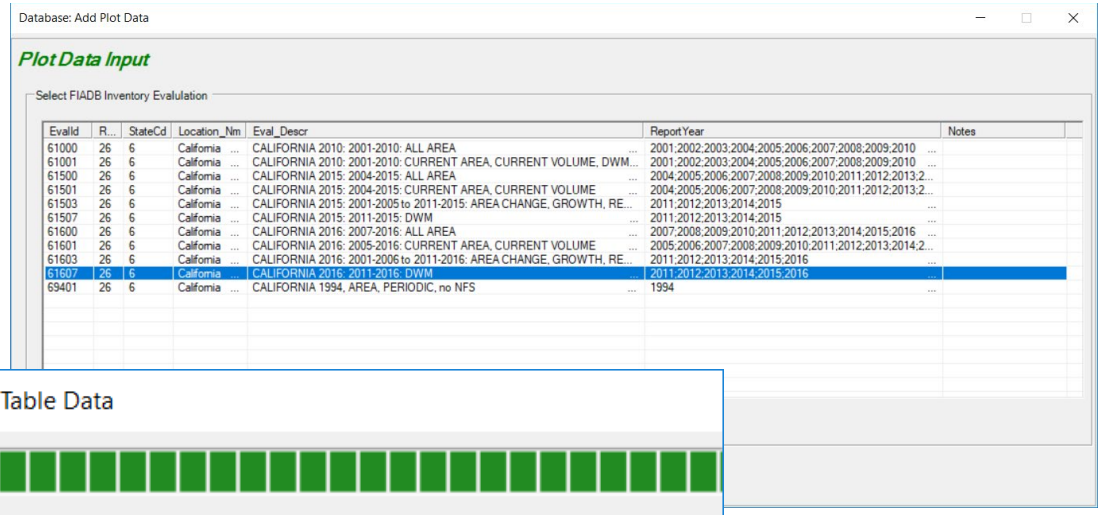
Standard BioSum version 5.8.7

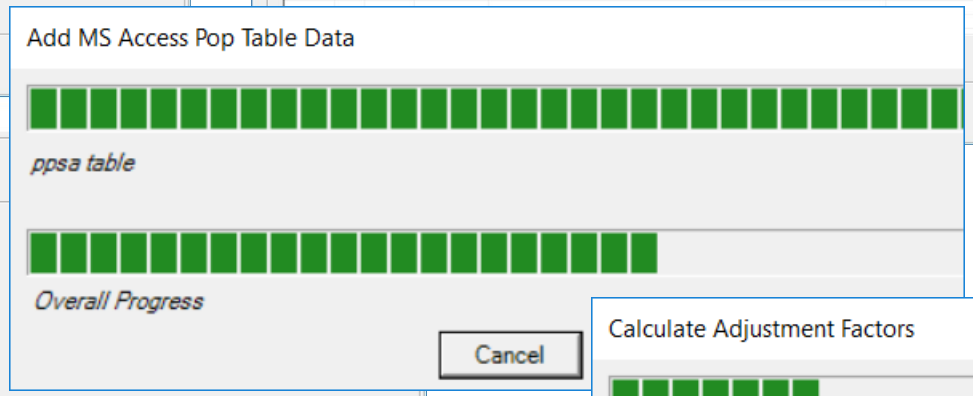


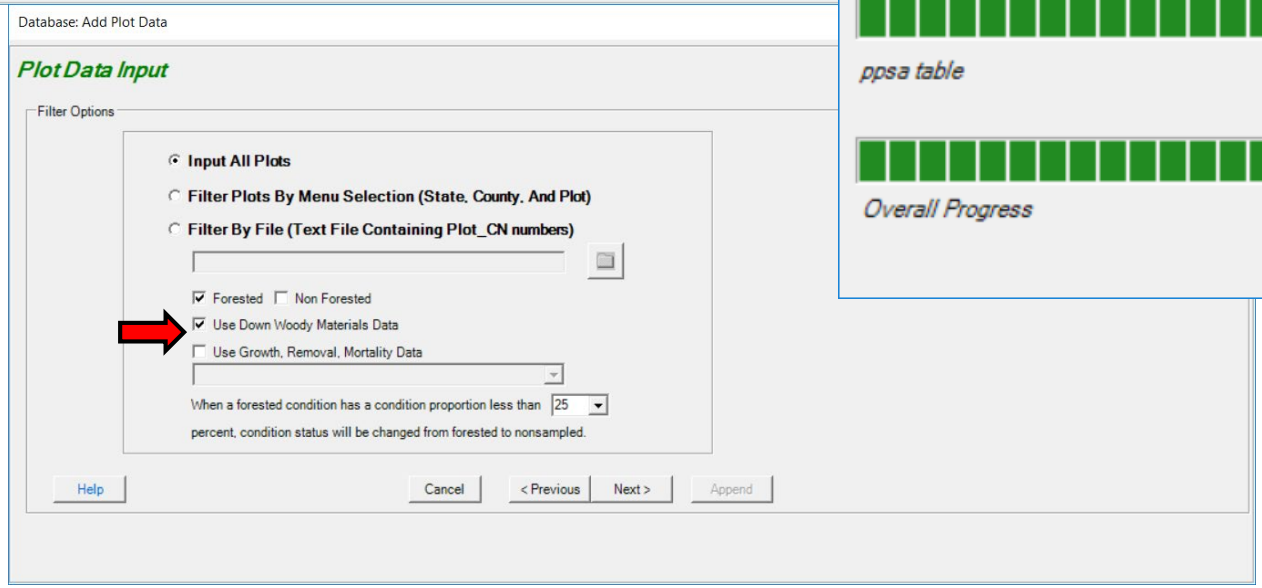
- Advantages
  - Proven, automated workflow
  - Easy to change problem definition, assumptions & rerun
  - Retains all intermediate calcs
- Limitations
  - "Biomass" def'n hard coded as all non-merch, including tops, limbs
  - Biochar: bolewood to a four inch DIB top, with a minimum length of eight feet, so typically a portion of top, or whole bole of non-commercial species
  - No harvest scheduling component

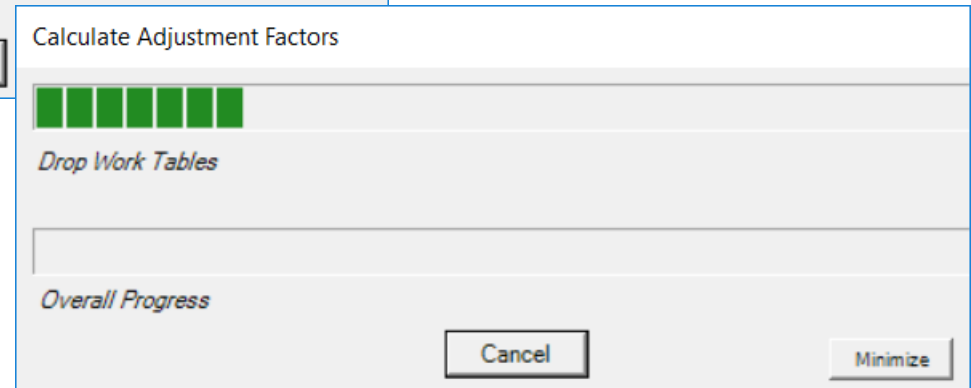
BioSum Database Module (FIADB loader)



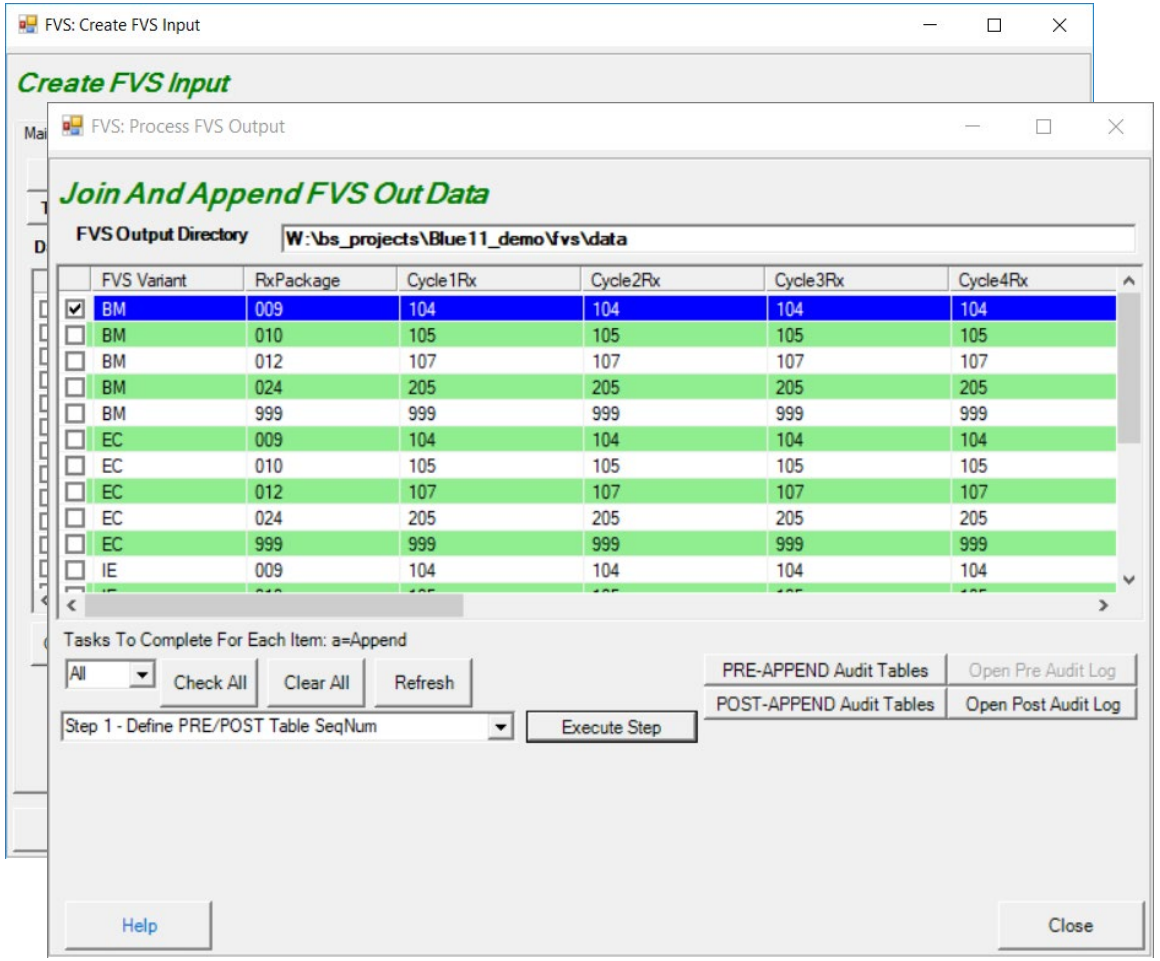


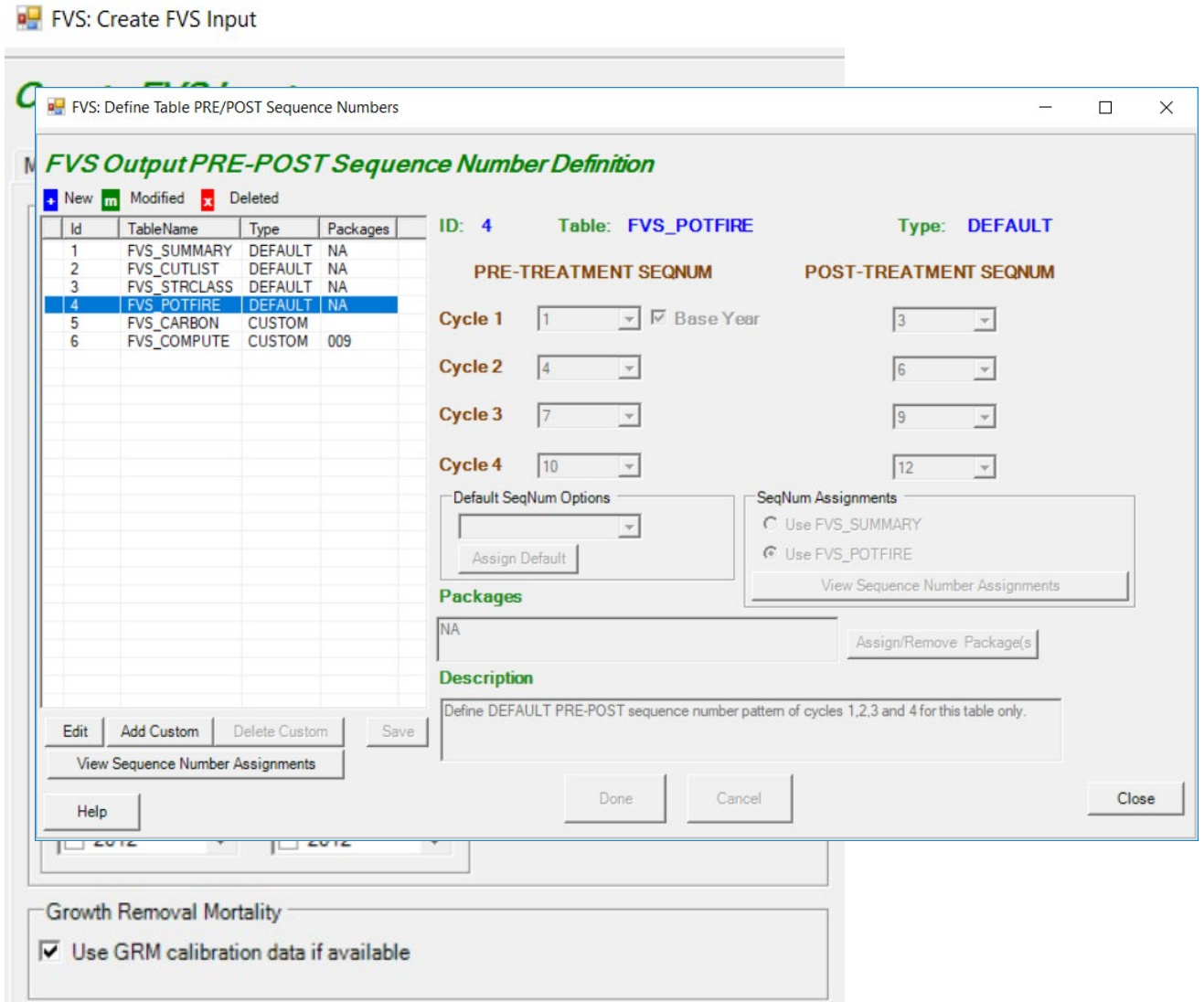




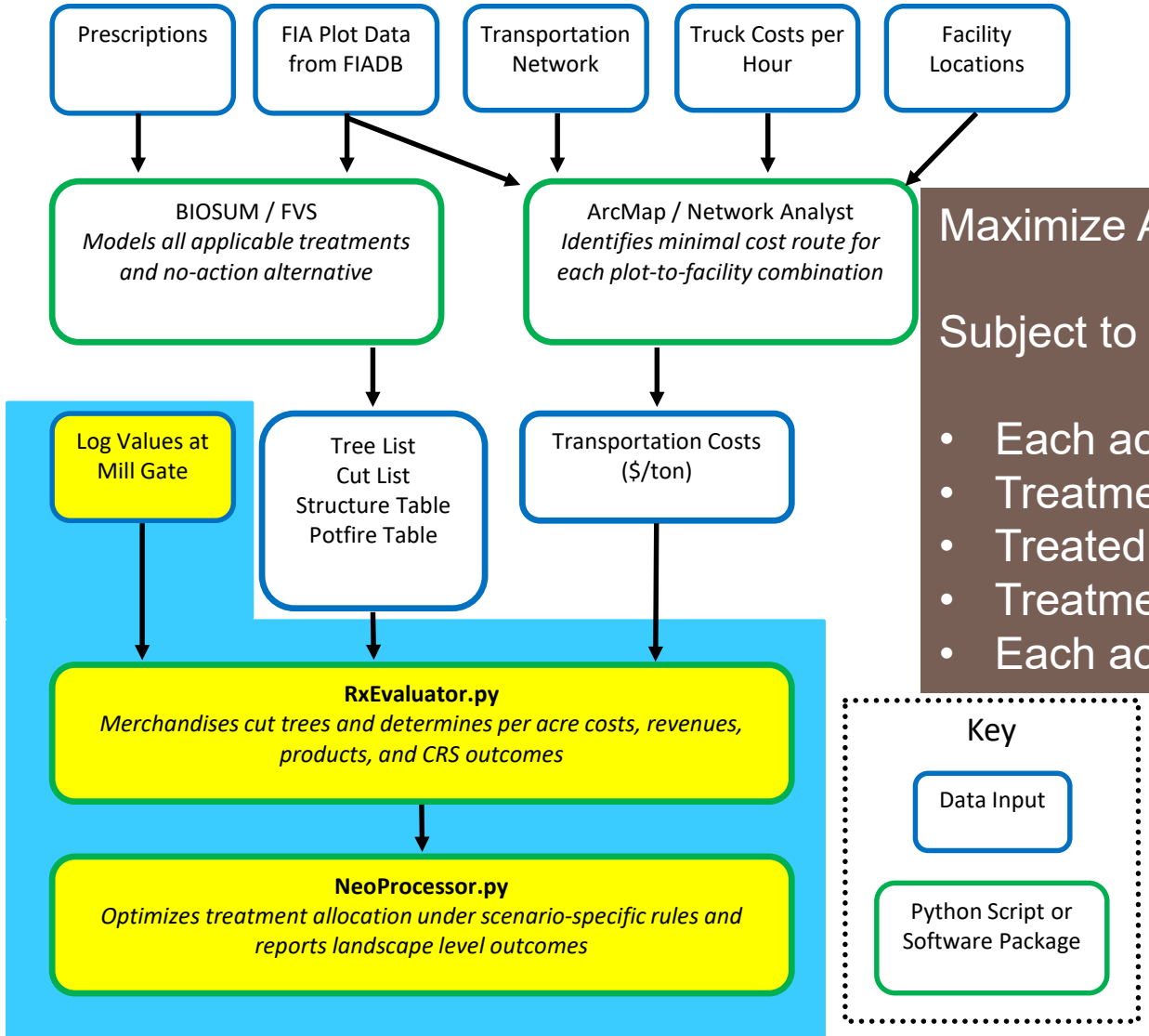


BioSum FVS Module





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 **≤ Treatment Capacity**
- Treated area **doesn't vary by more than 20%** per period
- Treatment **Cost ≤ 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

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

1-story

>1-story

>70% junk

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

Fire resistance scoring:
∑ subscores→ **C**omposite **R**esistance **S**core[1] 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 treated (ac.)	Management Return 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

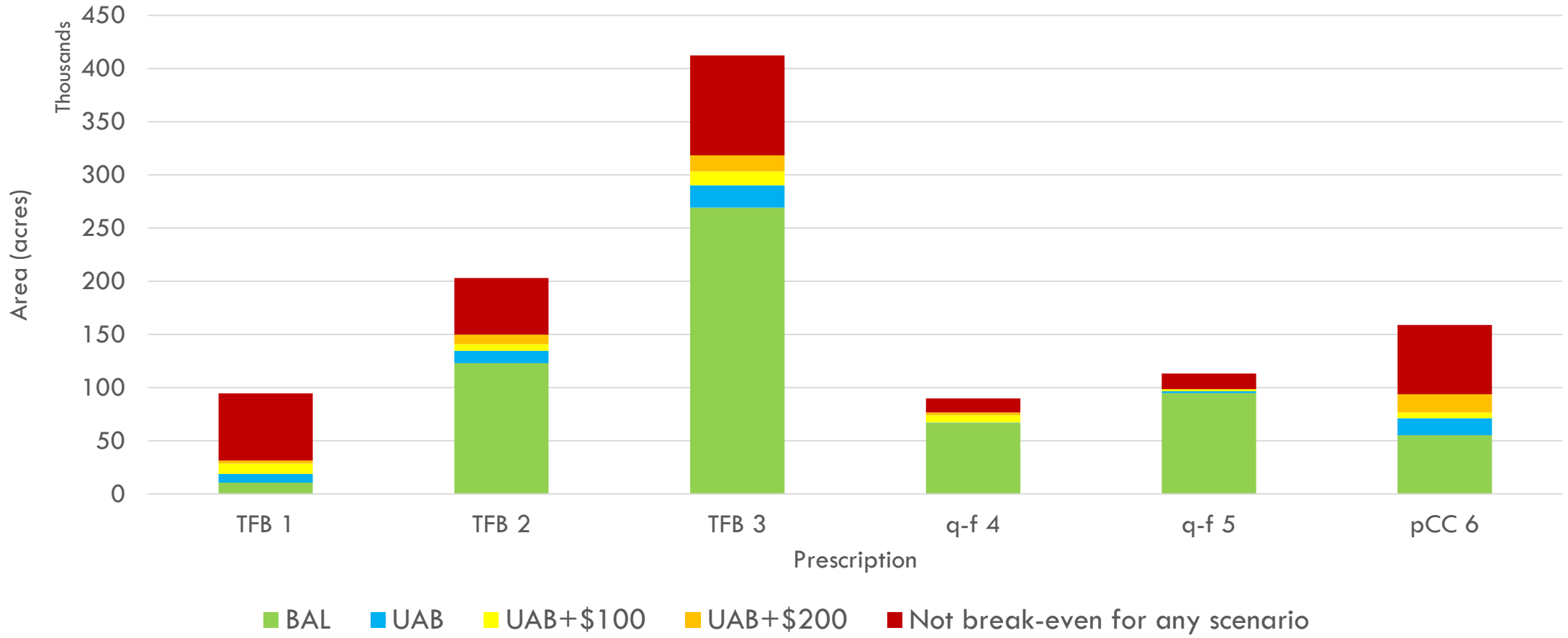
Immediate score change relative to grow-only when implemented at year 1

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
nCC 6	0.34	0.73	2.49	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

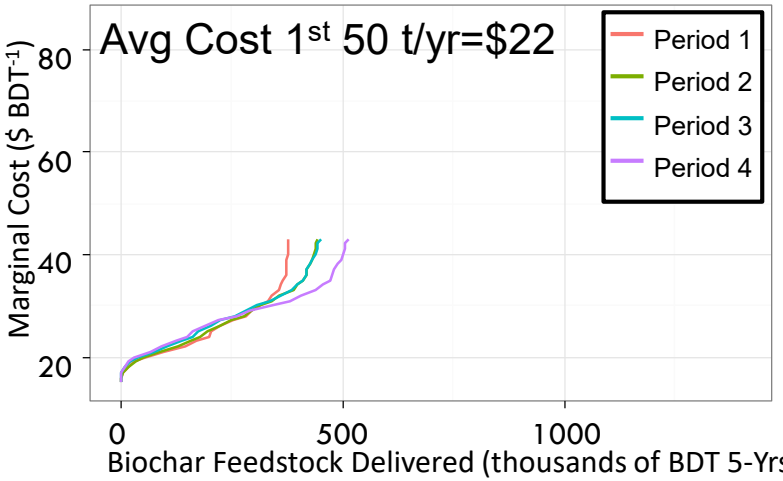
[1] at discount rate of 3%

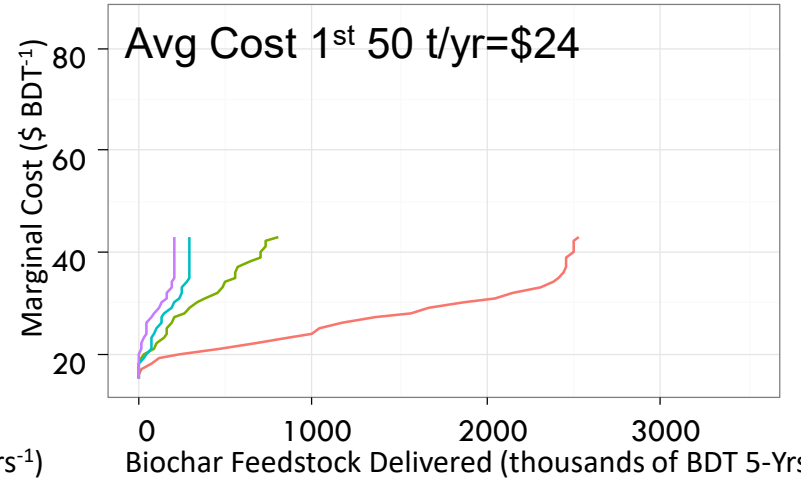
Annual wood production

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

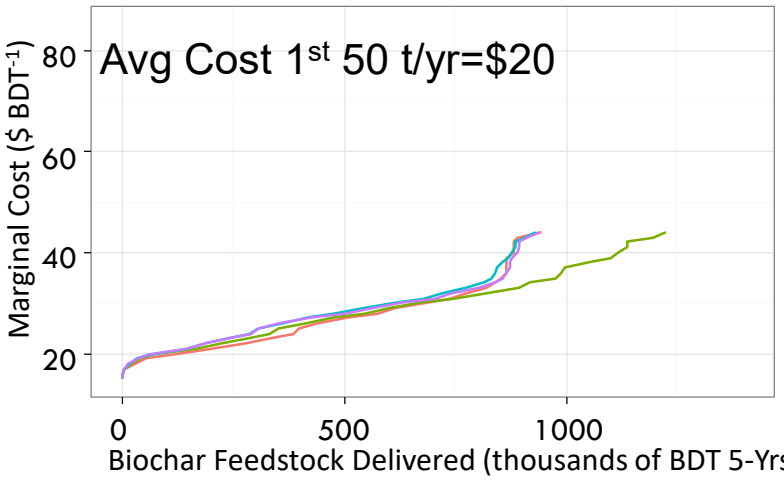
100-yr management return interval; loading and hauling costs only

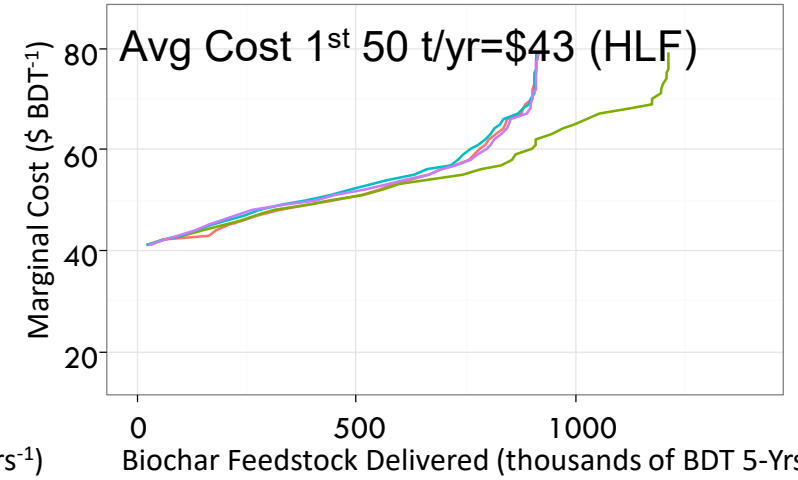




Unconstrained treatment capacity; loading and hauling costs only

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 ≥ 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