Building the ECON Extension – Functionality and Lessons Learned

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Prophecy versus Perspective

Predictions are fictional constructs that may have applications in the real world.

"Prediction is difficult, especially if it concerns the future." Francis Crick.

“Expositions of the future tell more about what we are, than about what we will become.” Daniel Gilbert.

Some clients view model results as predictions of what is to come - belief in absolute values.

"To try to do something which is inherently impossible is always a corrupting enterprise." Michael Oakshott.

Prophecy versus Perspective

"Models provide a means to better represent existing information." Al Stage.

"The purpose of calculation is insight, not numbers." Unknown

"I believe the best test of a model is how well can the modeler answer the questions 'What do you know now that you did not know before?' and 'How can you find out if it is true?'" James M. Bower.

Some clients use models to choose among alternative actions or directions - acceptance of relative values.

“The myth of comprehensive planning versus the science of muddling through.” Richard Behan.

Integrated Example – FVS, FFE, ECON

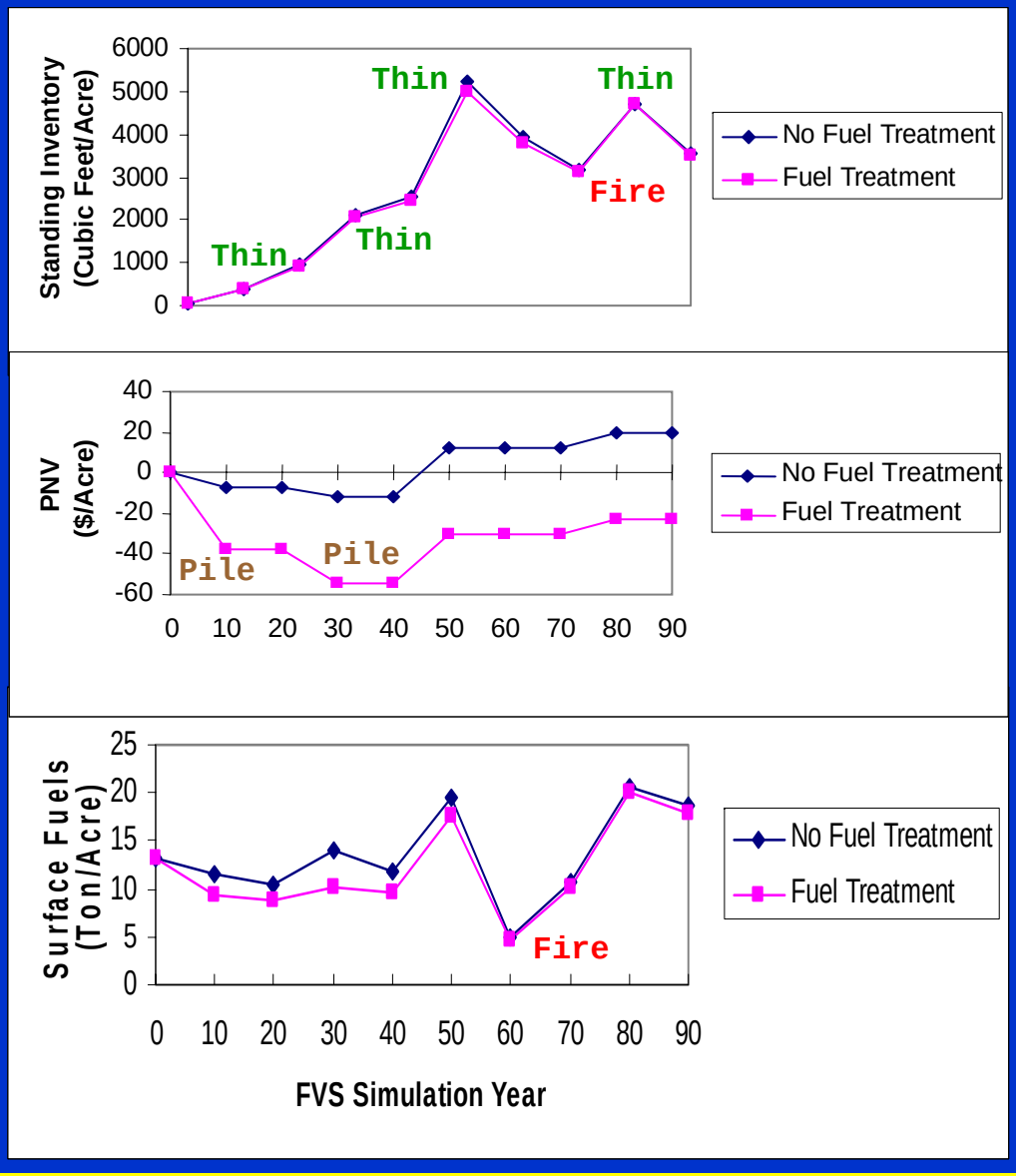
Examine economic and biological effects of alternative fuel strategies.

Young, mixed-species stand.

“No Fuel Treatment” thinned at 10, 30, 50 and 80 years, with wildfire in year 60.

“Fuel Treatment” same thinning & wildfire, but pile/burning treatments following 10 & 30-year thinning.

Integrated Example



History

FVS Post-Processor

- CHEAPO I (Horn et al., 1986)
- CHEAPOII (Medema and Hatch 1982)

FVS Integration

- SCOPING (Crookston, Wiitala, Barber, Hotvedt, and Martin)
- ECON 0.5 (Renner, 2001)
- ECON 1.0 (Martin and Lu, 2005)

Why Econ - Motivating Questions

Given an existing stand, when is the economically efficient harvest time?

What is the value of forestland for timber production?

Given an existing stand and its forestland value, when is the economically efficient harvest time?

Given harvest deferral of an existing stand until a target condition is achieved, what is the forestland value for timber production that maintains the target condition?

Given an existing immature stand having a known land value, what is the value of the immature trees ("reprod" value)?

Example 1 – when to harvest?

Objective - maintain continuous tree cover.

Assume 400 pole-sized trees per acre.

Prescription: harvest 90% of the basal area between diameter limits that vary over time, e.g.:

- **In 2004 harvest 90% of the basal area in trees 6-16” DBH.**
- **In 2054, harvest 90% of the basal area in trees 6-22” DBH.**

“Pretend” harvest simulated each cycle.

Example 1 – FVS Measures

Year	Trees /Acre	Basal Area/ Acre	Total Bd Ft /Acre	Accretion Cu Ft/ Acre/Yr	Mortality Cu Ft/ Acre/Yr	Harvest Bd Ft /Acre
2004	400	127	19,300	122	24	11,112
2014	305	148	24,765	124	32	14,177
2024	241	166	29,836	118	43	16,545
2034	197	179	34,618	124	57	18,825
2044	163	188	39,036	123	60	18,575
2054	139	195	43,162	124	66	24,831
2064	120	201	47,317	111	72	31,156
2074	105	203	50,686	108	81	37,591
2084	92	202	52,993	104	81	39,669
2094	81	201	55,724	98	82	44,833

Example 1 – ECON Measures

Year	Harvest Bd Ft /Acre	PNV	Internal Rate of Return	B/C Ratio	Realizable Rate of Return
2004	11,112	31	>50.0	1.03	4.4
2014	14,177	106	34.5	1.14	4.7
2024	16,545	131	15.9	1.23	4.7
2034	18,825	100	9.8	1.23	4.5
2044	18,575	59	6.7	1.20	4.4
2054	24,831	95	6.7	1.36	4.5
2064	31,156	142	6.7	1.62	4.7
2074	37,591	135	6.1	1.68	4.7
2084	39,669	100	5.5	1.62	4.6
2094	44,833	79	5.1	1.56	4.5

Example 2 - forestland value?

What is the soil expectation value (SEV) of a perpetually repeating prescription?

Initial conditions: residual 16 TPA, 5-21” DBH.

Prescription: plant & natural regeneration, commercial thinning 2034, & final harvest to replicate initial stand conditions.

“Pretend” final harvests simulated each cycle beginning in 2044.

Each “pretend” cycle is a mutually exclusive prescription, e.g., a repeating 80-year rotation, or a repeating 90-year rotation, but not both.

Table 2 – FVS Measures

Year	Trees /Acre	Basal Area/ Acre	Total Bd Ft /Acre	Accretion Cu Ft /Acre/Yr	Mortality Cu Ft/ Acre/Yr	Harvest Bd Ft /Acre
2004	16	14	2,350	18	2	0
2014	1,464	19	3,302	42	0	0
2024	1,805	42	4,453	133	1	0
2034	1,388	106	7,993	65	2	1,842*
2044	122	57	9,376	90	5	6,792
2054	113	81	13,770	111	8	10,167
2064	107	107	19,264	123	13	14,640
2074	101	133	25,518	139	21	19,964
2084	96	158	32,796	151	29	26,538
2094	91	182	40,335	152	38	32,756

* Actual harvest

Example 2 – ECON Measures

Year	Investment Period	Harvest Bd Ft /Acre	PNV	SEV	Internal Rate of Return
2004	10	0	-68	-209	
2014	20	0	-76	-141	
2024	30	0	-80	-116	
2034	40	1,842*	-60	-76	<0.0
2044	50	6,792	117	136	6.6
2054	60	10.167	124	137	6.2
2064	70	14,640	136	145	5.9
2074	80	19,964	147	154	5.7
2084	90	26,538	148	152	5.5
2094	100	32,756	128	131	5.3

* Actual harvest

Example 3 – future prescription?

When to replace a current stand with a perpetual prescription?

Assume 400 pole-sized trees per acre.

Prescription: reserve 16 large TPA.

“Pretend” harvest each cycle.

SEV from Example 2 ($154).

Influence of future stands is considered.

"Value of forest" measures the economically efficient time to convert the existing stand.

“Value of forest” equals PNV plus the discounted SEV (value of trees plus value of land).

Example 3 – ECON Measures

Year	Investment Period	Harvest Bd Ft/ Acre	PNV	Value of Forest	Delay Period
2004	10	17,006	221	391	1
2014	20	21,678	241	356	11
2024	30	26,248	298	375	21
2034	40	30,438	370	422	31
2044	50	33,957	380	415	41
2054	60	36,923	363	387	51
2064	70	40,251	322	339	61
2074	80	42,377	249	260	71
2084	90	43,357	190	197	81
2094	100	44,376	135	140	91

Example 4 – maintain a future forest?

If harvest deferred until some stand target; what is SEV that maintains the target condition?

Assume 400 pole-sized trees per acre.

Prescription: harvest all but 16 sixteen largest trees when 10% of trees >= 21” DBH, and regenerate stand.

Event Monitor tracks target condition to determine time of harvest, and “triggers” ECON keywords (SEVSTART and PRETEND).

“Pretend” harvest at each cycle is mutually exclusive perpetual management alternative of different harvest age.

Example 4 – FVS Measures

Year	Trees /Acre	Basal Area/ Acre	Total Bd Ft /Acre	Harvest Bd Ft /Acre
2004	160	139	23,500	
2014	143	153	28,771	
2024	128	165	33,358	
2034	115	174	37,805	28,044*
2035	16	33	9,702	
2044	2,023	39	11,999	
2054	2,133	52	14,452	
2064	1,620	90	18,024	
2074	1,359	150	23,866	
2084	1,163	212	31,512	9,445
2094	983	264	39,924	16,390
2104	824	304	47,292	22,110
2114	690	330	54,183	27,823
2124	579	349	61,083	33,043

* Actual harvest

Example 4 – ECON Measures

Year	Invest-ment Period	Harvest Bd Ft /Acre	PNV	Internal Rate of Return	Realizable Rate of Return	SEV
2004	10		0			
2014	20		0			
2024	30		0			
2034	31	28,044*	1,571	>50.0	10.2	
2035	9		-48			-162
2044	19		-48			-92
2054	29		-48			-71
2064	39		-48			-61
2074	49		-48			-56
2084	59	9,445	91	6.3	4.9	101
2094	69	16,390	168	6.7	5.1	180
2104	79	22,110	182	6.4	5.2	190
2114	89	27,823	175	6.0	5.1	181
2124	99	33,043	151	5.7	5.0	154

* Actual harvest

Example 5 – "reprod" value

Value of immature trees ("reprod" value) when bare land value (SEV) is known?

Well-stocked pole-size stand with little merchantable volume & SEV of $154.

Value has two components, NPV of existing timber & discounted SEV of future stand.

Value as of today if sold or destroyed – "value at risk."

Value depends on expected harvest date & hence delay of future prescription (SEV).

Example 5 – "reprod" value

Year	Invest -ment Period	Basal Area/ Acre	Total Bd Ft /Acre	Harvest Bd Ft/ Acre	PNV	Value of Forest	Value of Trees
2004	10	111	3,900	3,572	35	183	29
2014	20	188	7,276	6,887	118	218	64
2024	30	239	11,917	11,281	254	322	168
2034	40	271	16,475	15,564	368	414	260
2044	50	287	21,605	20,246	408	438	284
2054	60	294	24,986	23,171	362	383	229
2064	70	294	28,482	26,079	307	321	167
2074	80	295	31,776	28,700	250	260	106
2084	90	293	35,637	31,670	197	203	49
2094	100	294	39,594	34,644	148	152	-2

Program Features

Pretend Harvests

Commercial vs. Pre-commercial Thinning

Multiple Types of Costs & Revenues

Value Rate Changes & Durations

Specifying ECON Start Times & Re-initialization

Volume Valuation

Economic Summary Table

FVS/ECON EXTENSION VERSION 1.0

STAND ID: Example_4 MANAGEMENT CODE: NONE - Dynamically initiate a future perpetual prescription

ECONOMIC ANALYSIS SUMMARY TABLE (DISCOUNT RATE: 4.0%)

YEAR	INVEST-MENT PERIOD	PRETEND MODE IS ACTIVE	UNDISCNTED VALUES COSTS	UNDISCNTED VALUES REVENUES	PRESENT VALUES COSTS	PRESENT VALUES REVENUES	PNV	INTERNAL RATE OF RETURN %	B/C RATIO	REALIZABLE RATE OF RETURN %	SEV	VALUE OF FOREST	VALUE OF TREES
2004	10	NO	0	0	0	0	0						
2014	20	NO	0	0	0	0	0						
2024	30	NO	0	0	0	0	0						
2034	31	NO	1062	6361	315	1886	1571	> 50.0	5.99	10.2			
2035	9	NO	50	0	48	0	-48		0.00		-162		
2044	19	YES	50	0	48	0	-48		0.00		-92		
2054	29	YES	50	0	48	0	-48		0.00		-71		
2064	39	YES	50	0	48	0	-48		0.00		-61		
2074	49	YES	50	0	48	0	-48		0.00		-56		
2084	59	YES	684	1622	137	228	91	6.3	1.66	4.9	101		
2094	69	YES	1110	3337	149	317	168	6.7	2.13	5.1	180		

STAND ID: Example_3 MANAGEMENT CODE: NONE - Economically efficient time to implement perpetual prescription

ECONOMIC ANALYSIS SUMMARY TABLE (DISCOUNT RATE: 4.0%, FOREST/TREE VALUES BASED ON USER-SUPPLLIED SEV: $154)

YEAR	INVEST-MENT PERIOD	PRETEND MODE IS ACTIVE	UNDISCNTED VALUES COSTS	UNDISCNTED VALUES REVENUES	PRESENT VALUES COSTS	PRESENT VALUES REVENUES	PNV	INTERNAL RATE OF RETURN %	B/C RATIO	REALIZABLE RATE OF RETURN %	SEV	VALUE OF FOREST	VALUE OF TREES
2004	10	YES	1181	1407	1131	1352	221	> 50.0	1.20	5.9		391	237
2014	20	YES	1454	1828	946	1187	241	46.6	1.25	5.2		356	202
2024	30	YES	1620	2328	723	1022	298	21.2	1.41	5.2		375	221
2034	40	YES	1753	3082	543	914	370	14.8	1.68	5.4		422	268
2044	50	YES	1801	3868	395	775	380	11.4	1.96	5.4		415	261

HARVEST VOLUME & GROSS VALUE

HARVEST VOLUME AND GROSS VALUE TABLE

YEAR = 2034 - PRETEND HARVEST: NO

SPECIES	SMALL-END DIB MIN	SMALL-END DIB MAX	TREE DBH MIN	TREE DBH MAX	TPA REMOVED	TPA VALUE $	TONS/ ACRE	CU FT REMOVED	CU FT VALUE $	BD FT REMOVED	BD FT VALUE $	TOTAL VALUE $
DF			6.0	10.0	14	0						0
DF			10.0	20.0	65	0						0
DF			20.0	999.9	10	0						0
DF	4.0	10.0								5203	780	780
DF	10.0	16.0								14497	4349	4349
DF	16.0	18.0								1055	369	369
DF	18.0	20.0								115	46	46
DF	0.0	999.9						3783	0			0
WH			0.0	999.9	10	0						0
WH	6.0	10.0								407	20	20
WH	10.0	20.0								5889	589	589
WH	20.0	999.9								795	199	199
WH	4.0	8.0						111	0			0

ECON Functionality

Ability to evaluate multiple harvest scenarios within a single simulation.

Ability to dynamically initiate and value future management prescriptions.

Ability to schedule management activities with the Event Monitor based on economic measures.

Ability to compute special costs and revenues in response to simulated events.

Lessons Learned

Paradigm shift - FVS is a modeling environment or framework not just a tree growth model.

Value lies in examining as wide a range of actions & measures as possible.

Growth precision is secondary to model operation and flexibility.

Outputs are less a statement of future conditions than quantification of marginal effects.

User's need to understand sequence and cycling of model operation.

Suggestions

Competition should focus on tree growth equations not modeling environments.

“Plug & Play” for growth generators to encourage better science – empirical and mechanistic.

Evolve the framework – refactor and deprecate.

- **Refactoring: a disciplined process that improves system structure but does not change behavior or introduce bugs.**
- **Deprecate: computer statements made invalid and obsolete overtime.**

Establish coordinating group to oversee model evolution, not just new features.

Model/Modeler Limitations

"At times I even persuade myself that I can glimpse some of the answers, but this is a common delusion experienced by anyone who dwells too long on a single problem." Francis Crick.

"Give me a fruitful error any time, full of seeds, bursting with its own corrections. You can keep your sterile truths for yourself." Vilfredo Pareto.

"66% of teenagers will have sex before they graduate from high school, 32% will have sex sometime later in life, and the remaining 2% will become statisticians." Jon Stewart.