De-Risking Biomass Feedstock Supply Chains:
How Advanced Predictive Analytics© Can Lower Debt Cost

Jordan Solomon

Managing Director & CEO

Ecostrat Inc.

Honeywell

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Leaf

Coca-Cola

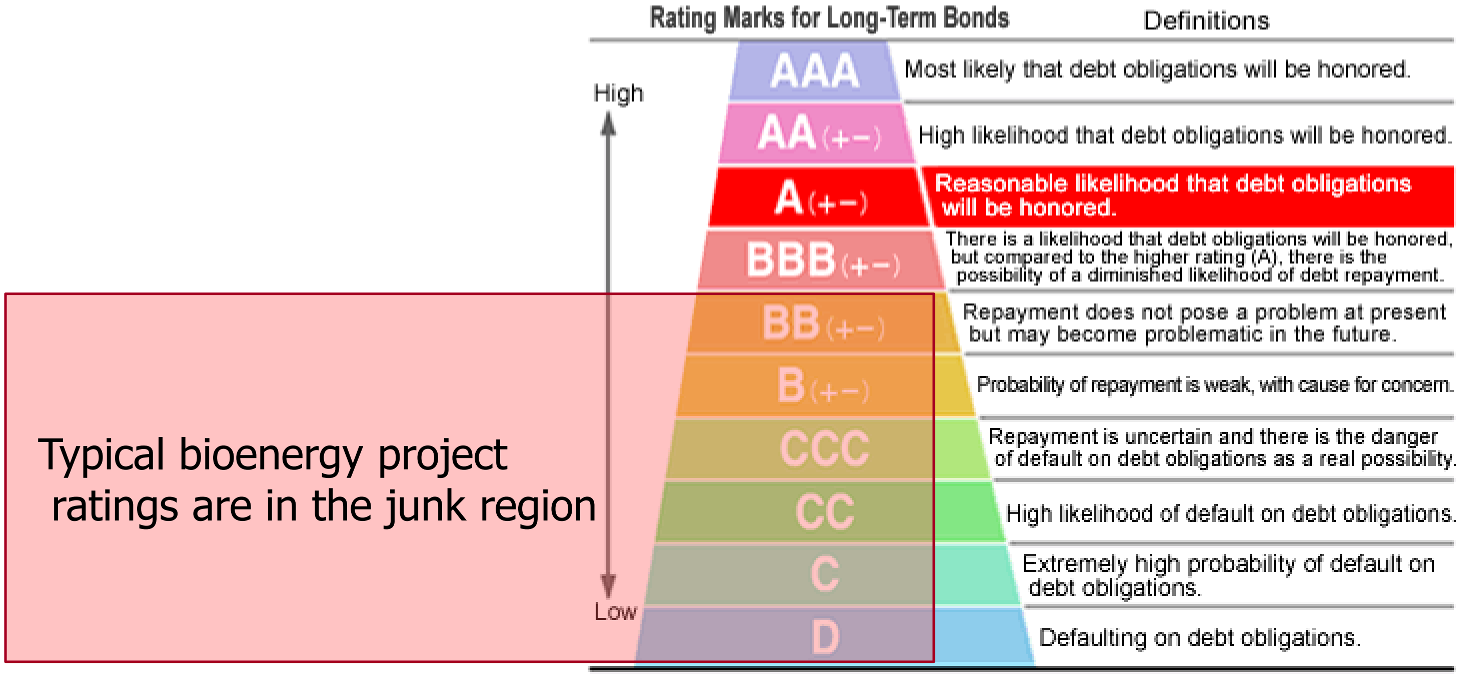
ZILKHA
BIOMASSENERGY

MACQUARIE

PG&E
Pacific Gas and Electric Company

eDF
energies nouvelles

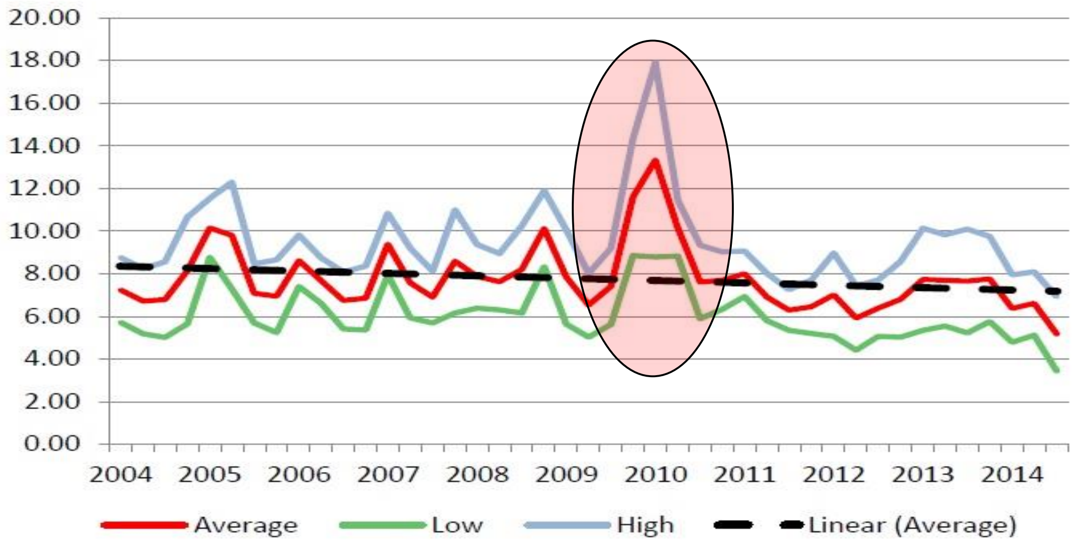
Most Bioenergy Projects Carry BB Rating or less ~ Junk



Note: Credit ratings range from AAA to D, and are further subdivided into a total of 20 ratings (see chart) by the use of plus and minus signs for ratings AA to B.

How do you predict this?

Figure 5: 10-year Historical Nominal Cost of Pine Pulpwood Stumpage (Present $/ton)



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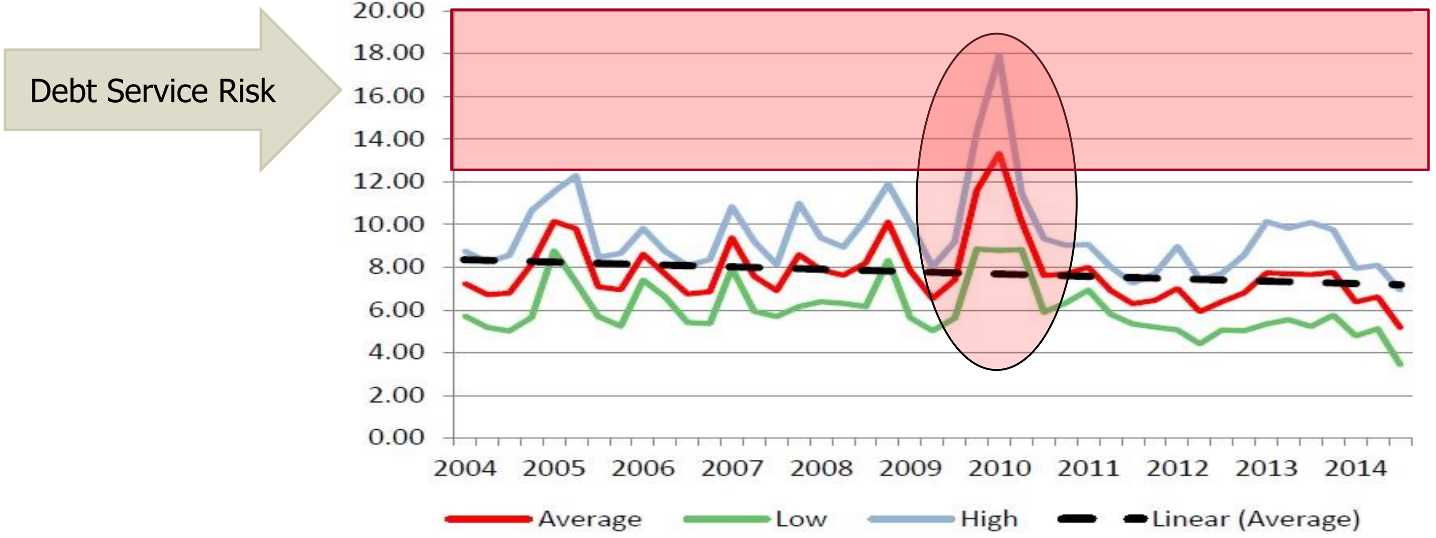
Why is this Important?

Figure 5: 10-year Historical Nominal Cost of Pine Pulpwood Stumpage (Present $/ton)



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Would you trust this?

$$\Delta G = (V_{\text{bound}}^{L-L} - V_{\text{unbound}}^{L-L}) + (V_{\text{bound}}^{P-P} - V_{\text{unbound}}^{P-P}) + (V_{\text{bound}}^{P-L} - V_{\text{unbound}}^{P-L} + \Delta S_{\text{conf}})$$

$$V = W_{\text{vdw}} \sum_{i,j} \left(\frac{A_{ij}}{r_{ij}^{12}} - \frac{B_{ij}}{r_{ij}^{6}} \right) + W_{\text{hbond}} \sum_{i,j} E(t) \left(\frac{C_{ij}}{r_{ij}^{12}} - \frac{D_{ij}}{r_{ij}^{10}} \right) + W_{\text{elec}} \sum_{i,j} \frac{q_i q_j}{\varepsilon(r_{ij}) r_{ij}} + W_{\text{sol}} \sum_{i,j} (S_i V_j + S_j V_i) e^{(-r_{ij}^2/2\sigma^2)}$$

So… how do we solve for uncertainty in the supply chain?

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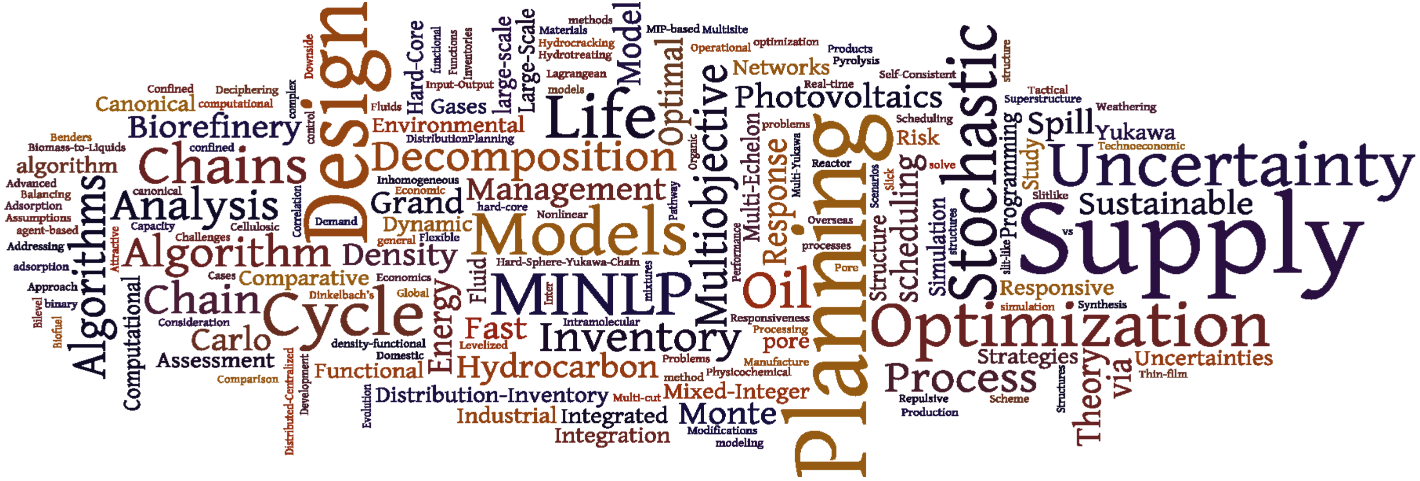
Complexity x Uncertainty = "Best Guess"



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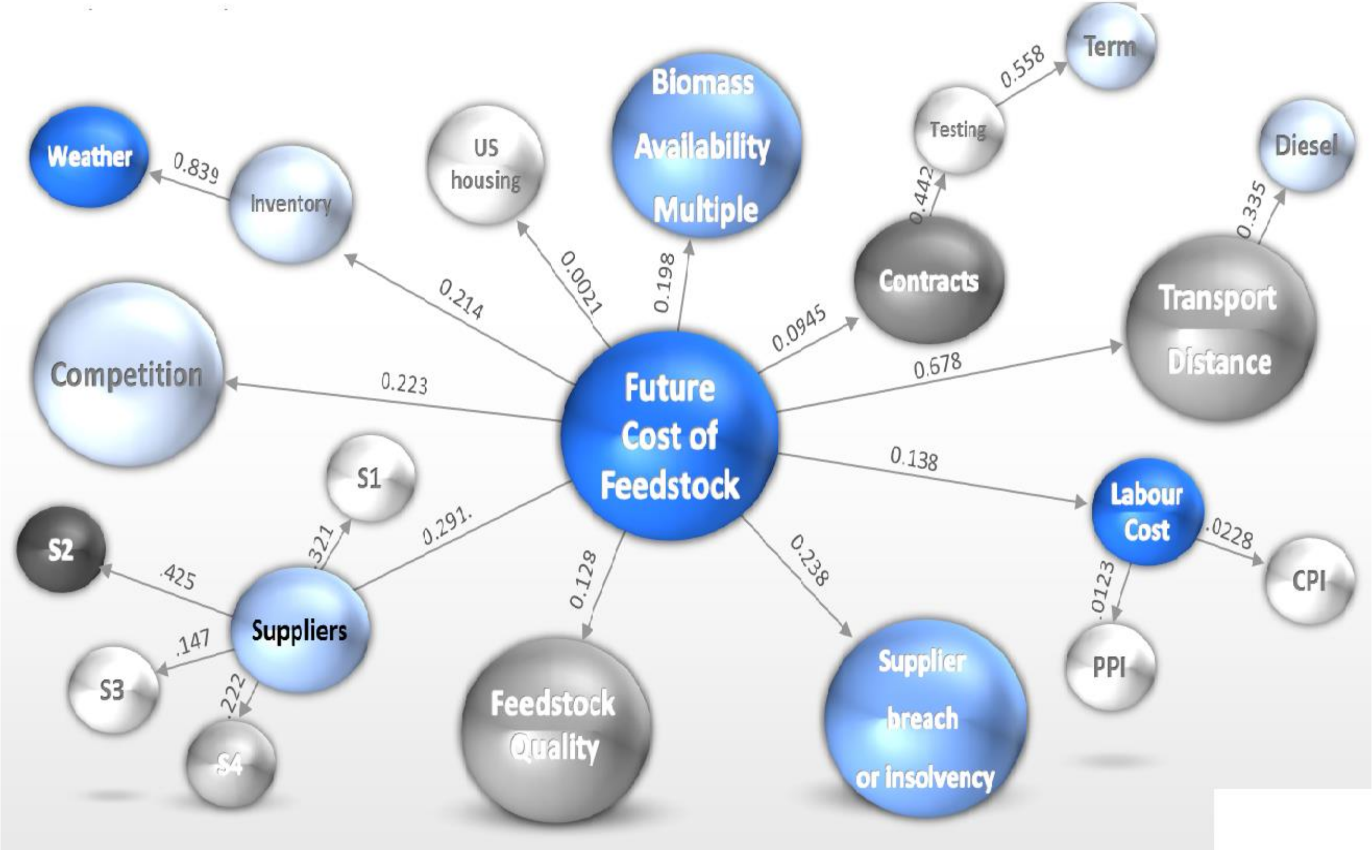
Biomass Supply Chain Risk: Complexity

Multiple components with indeterminate risk of occurrence and impact



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In the real world, questions about feedstock risk are simple

- What is the likelihood that feedstock price will exceed $x per bone dry ton over the next 10 years?
- How big is too big? What is the ideal plant size?
- What are the real risks to the feedstock supply?
- What is the vulnerability of the supply chain to a disruption risk?
- Which particular variable has the largest impact upon feedstock cost?
- What is the impact of various mitigation strategies on multiple disruption risks?
- What is the ideal supplier mix to minimize risk and cost?

The fact is that 10 experts can give 10 different opinions.

So…. What makes for reliable predictions in biomass feedstock?

And … When do you know you can trust the information?

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H3 =VLOOKUP(E3,$E$23:$F$28,2)

	Risk	Probability of risk (frequency)	Severity of risk (impact)	# events in 20 yrs (20)	% f'stock impacted	Mitigation 1	$	$ Low	$ High	Mitigation response	Mitigation 2	$	$ Low	$ High	Mitigation response		Tonnes impacted (709,655 tonnes)	Range Low $	Range High $	Premium $
1	Drought	2	5	2	50%	Alt reg	48	30	60	50%	HW	55	36	78	50%	Drought	354,828	1.63	3.45	2.57
2	Low yields	3	4	5	25%	Inv	15	11	30	50%	Exp area	3	3	3	50%	Low yields	177,414	0.43	1.01	0.55
3	Poor farming practices (weeds, disease, crop is cut too high, poor soil quality)	2	1	2	2%	Inv	15	11	30	50%	Exp area	3	3	3	50%	Poor farming practices	14,193	0.01	0.03	0.02
4	Crop rotation changes	1	1	1	2%	Exp area	3	3	3	100%	-	0	0	0	0%	Crop rotation changes	14,193	0.00	0.00	0.00
5	Competition offers more when agreement is being renewed	1	5	1	50%	Price incr	5	5	5	50%	Exp area	3	3	3	50%	Competition offers more	354,828	0.10	0.10	0.10
6	Farmer does not honor agreement or renew the agreement due to drop in humus value	3	1	5	2%	Exp area	3	3	3	100%	-	0	0	0	0%	Farmer not honor agreement (humus)	14,193	0.02	0.01	0.01
7	Farmer with agreement sells land and new land owner is not interested	3	1	5	2%	Exp area	3	3	3	100%	-	0	0	0	0%	Farmer sells land and new owner not interested	14,193	0.02	0.01	0.01
8	Farmer does not honor agreement or renew the agreement due to assumed loss in fertilizer value	2	3	2	10%	Exp area	3	3	3	100%	-	0	0	0	0%	Farmer not honor agreement (fertilizer value)	70,966	0.03	0.03	0.03
9	Farmer does not honor agreement or renew the agreement due to poor service provided by operators or plant	2	2	2	5%	Exp area	3	3	3	100%	-	0	0	0	0%	Farmer not honor agreement (poor service)	35,483	0.02	0.01	0.01
10	Fire (lightning) destroys inventory	2	3	2	10%	HW	55	36	78	100%	-	0	0	0	0%	Fire (lightning)	70,966	0.36	0.78	0.55
11	Fire (arson) destroys inventory	2	3	2	10%	HW	55	36	78	100%	-	0	0	0	0%	Fire (arson)	70,966	0.36	0.78	0.55
12	Degradation losses due to high moisture	3	2	5	5%	Inv	15	11	30	50%	HW	55	36	78	50%	Degradation losses high moisture	35,483	0.29	0.67	0.43
13	Wet baling season reduces available baling days	3	5	5	50%	Alt reg	48	30	60	40%	HW	55	36	78	60%	Wet baling season	354,828	4.15	8.85	6.50
14	Baling operators do not perform up to expected volumes	3	2	5	5%	HW	55	36	78	100%	-	0	0	0	0%	Baling operators do not perform	35,483	0.44	0.98	0.68
15	Price increase at contract renewal for baling contractors	3	2	5	5%	Price incr	5	5	5	100%	-	0	0	0	0%	Baling price increase	35,483	0.06	0.06	0.06
17	Transport is interrupted by weather, strike or other conditions	1	1	1	2%	Inv	15	11	30	100%	-	0	0	0	0%	Transport interruptions	14,193	0.01	0.03	0.02
18	Transport cost increases during	3	2	5	5%	Price incr	5	5	5	100%	-	0	0	0	0%	Transport cost increases	35,483	0.06	0.06	0.06

Impact Analysis :
Current and Additional Consumption on Supply

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Results

Description *(US Short Tons)*	Amount	Reference
Growth Drain Ratio (R2)	2.2	R2 = S16 / D6
Available Annual Supply (R3)	**2,600,000**	R3 = S16 - D6
Sustained Annual Harvest Plus Net Growth (S16)	4,800,000	S16 = S7 + S15
% Annual Net Growth after Removals (R1)	**2%**	R1 = S15 - S3
Annual net Growth after Removals (S15)	600,000	S15 = S14 - S3
Sustained Annual Pulpwood Harvest (without net growth) (S7)	4,300,000	S7 = S5 x S6
Competitive Annual Consumed Tons (D6)	**2,200,000**	D6 = D5 x D3
Annual Pulpwood Available for Harvest (S5)	8,700,000	S5 = S3 x S4
Total Ending Pulpwood (after removals plus growth) (S14)	32,100,000	S14 = S11 + S13
Total Beginning Pulpwood (S3)	31,500,000	S3 = (S2c / 100) x 3.37

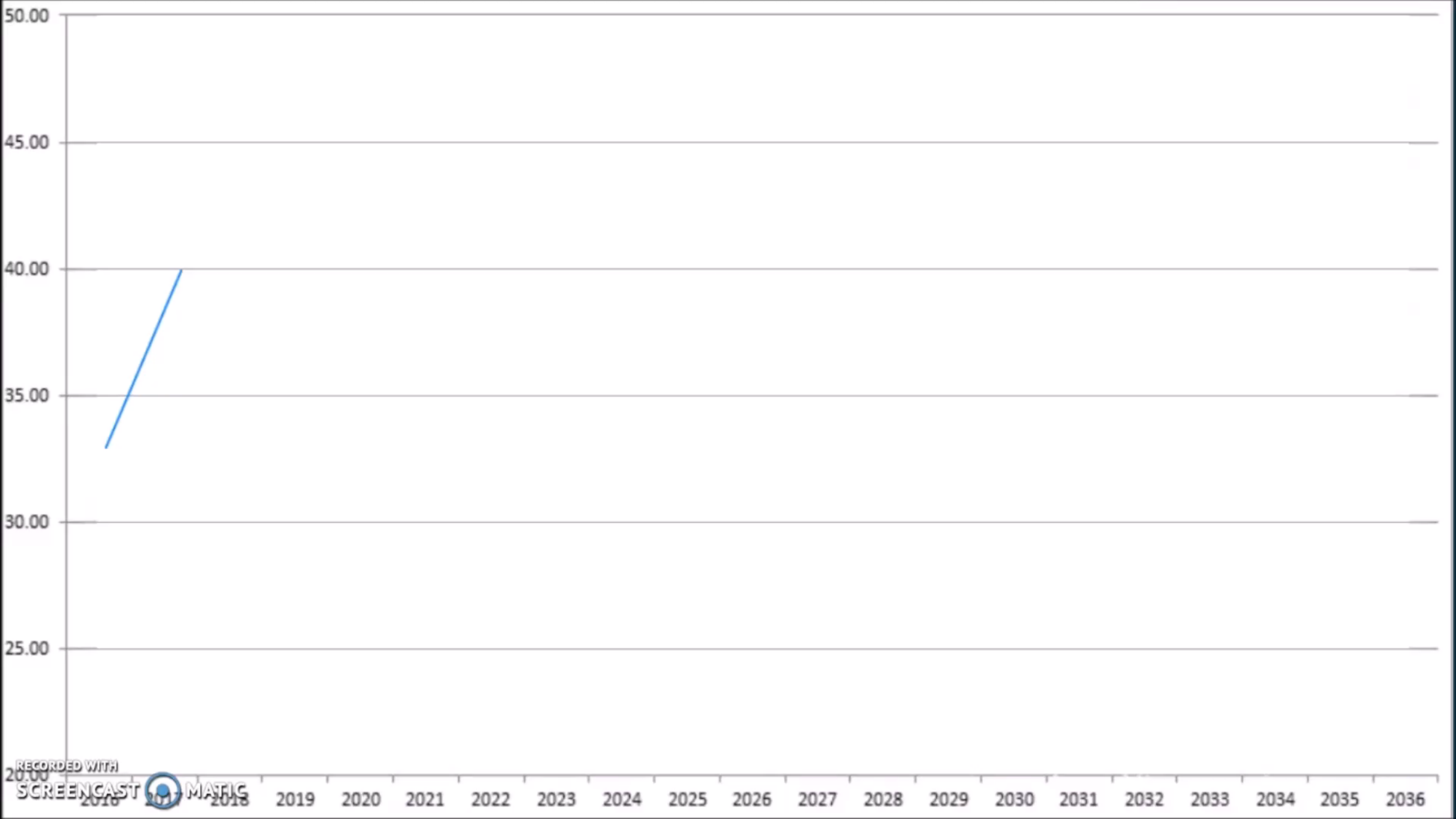
References:
- S = Supply
- D = Demand (Consumption)
- R = Results

Summary

Diameter Classes by Dbh		FIA Pulpwood Data			Total Beginning Pulpwood	Annual Pulpwood Available for Harvest		Sustained Annual Pulpwood Harvest (without net growth)		Pulpwood After Annual Harvest	Growth Shifting Dbh Classes		Total after Removal Plus Dbh Shift (before growth)	Growth Inside Dbh Classes		Total Ending Pulpwood *(after removals plus growth)*	Annual Net Growth after Removals	Sustained Annual Harvest Plus Net Growth
		only pulpwood trees ≥5.0" to 10.0" dbh inside each 2" dbh average quadratic mean class																
S1		S2a	S2b	S2c	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
US dbh Inches		S2c / S2c sum	FIA	S2b x 1,000,000	(S2c / 100) x 3.37	chart	S3 x S4	chart	S5 x S6	S3 - S7	chart	S8 x S9	(S8 - S10) + S10 preceeding dbh	chart	(S8 - S10) * S12	S11 + S13	S14 - S3	S7 + S15
2" Class	*Range*	*Percent*	*US Cubic Feet (million)*	*US Cubic Feet*	*US Tons*	*Percent*	*US Tons*	*Percent*	*US Tons*	*US Tons*	*Percent*	*US Tons*	*US Tons*	*Percent*	*US Tons*	*US Tons*	*US Tons*	*US Tons*
6	*5.0-6.9*	25%	236.4	236,400,000	7,966,680	4%	339,151	22%	74,285	7,891,685	37%	2,925,569	6,800,039	23.5%	1,168,360	7,968,399	1,719	76,004
8	*7.0-8.9*	48%	451.1	451,100,000	15,202,070	36%	5,510,189	34%	1,897,079	13,305,540	23%	3,002,159	13,228,949	12.8%	1,321,540	14,550,490	(651,580)	1,245,498
10	*9.0-10.9*	25%	230.3	230,300,000	7,761,110	34%	2,674,550	80%	2,134,715	5,646,472	19%	1,091,157	7,557,474	10.5%	477,438	8,034,912	273,802	2,408,518
12	*11.0-12.9*	2%	15.0	15,000,000	505,500	32%	163,782	93%	152,936	351,025	19%	66,628	1,375,554	7.6%	21,727	1,397,282	891,782	1,044,717
≥ 14	*≥ 13.0*	0%	3.3	3,300,000	111,210	31%	34,201	93%	31,940	79,734	0%	-	146,361	5.6%	4,486	150,847	39,637	71,578
		100%	936.1	936,100,000	**31,546,570**		8,721,873		4,290,955	27,274,455		7,085,513	29,108,378		2,993,552	**32,101,930**	555,360	4,846,315

% Annual Net Growth after Removals (R1 = S15 / S3):	**2%**
% of total Beginning Pulpwood (S16 / S3):	15.4%
Weighted Mean Average Biological Growth Cross-Check (refer to chart "Growth Percents):	14.9%
% Variance between two methods (variance less than "1%" no adjustments required):	0.44%


NOWHERE
SOMEWHERE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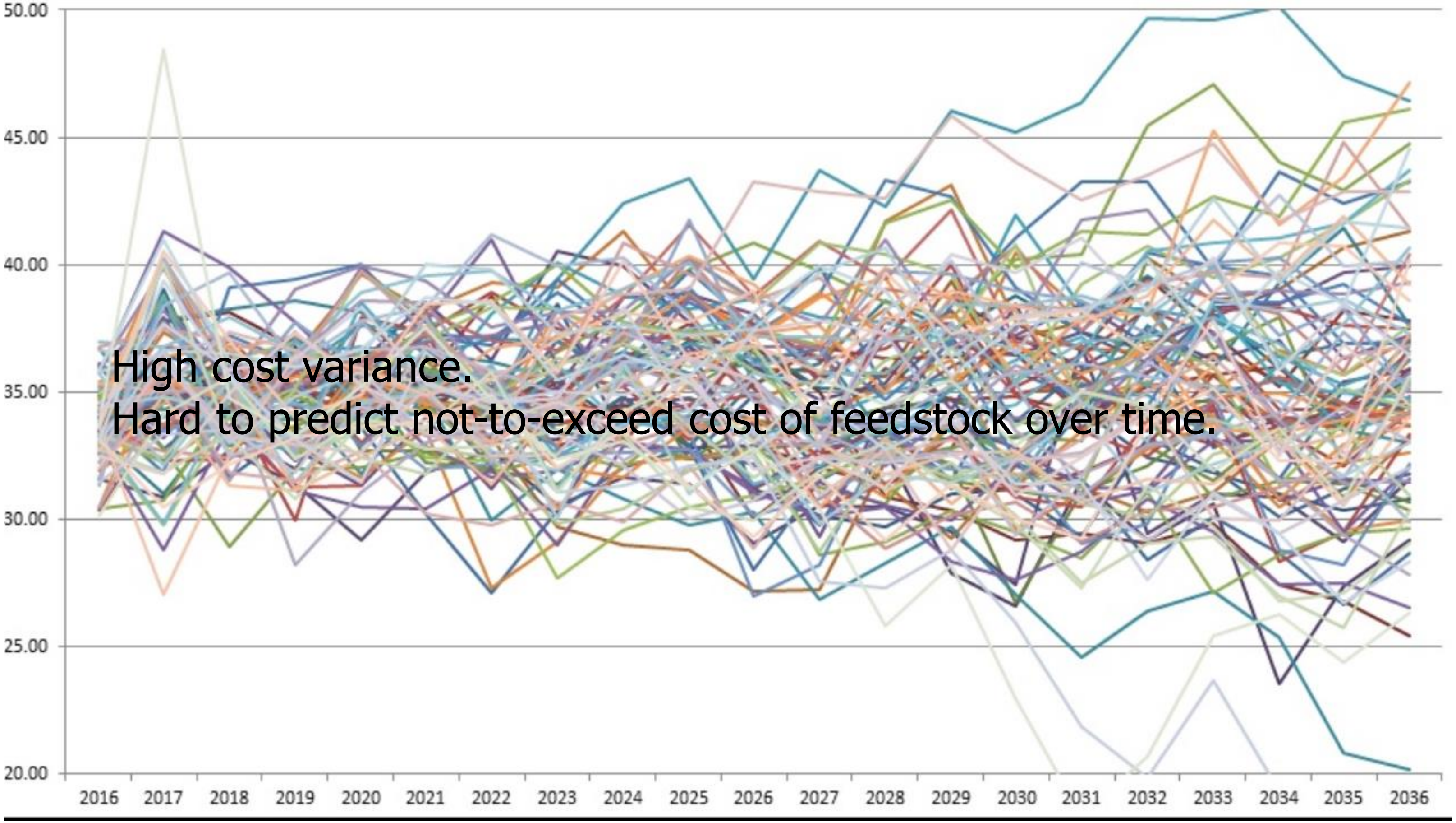
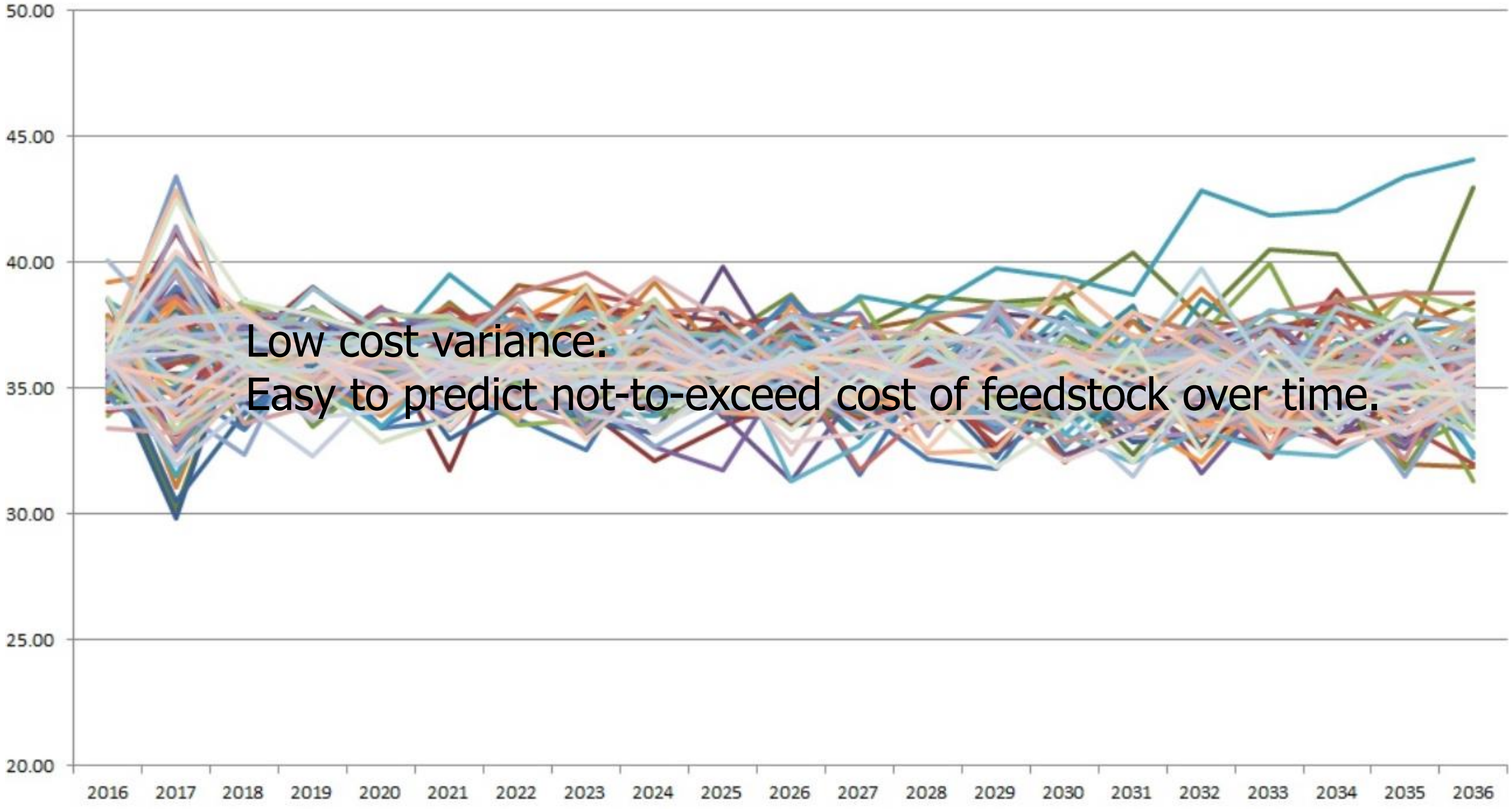
20 Yr Supply Chain Risk in US (risk pathways with typical stumpage variance)

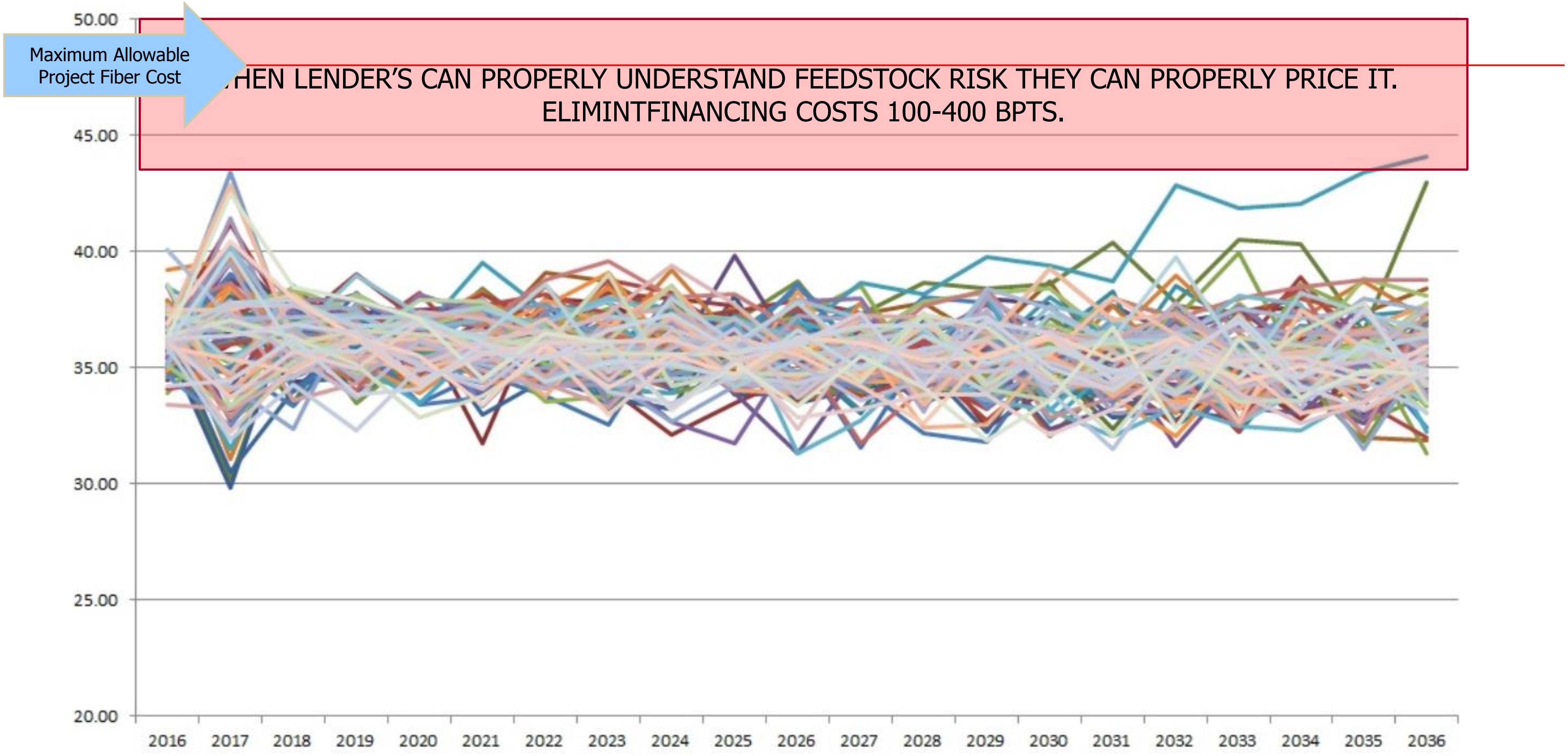


High cost variance.
Hard to predict not-to-exceed cost of feedstock over time.

20 yr Supply Chain Risk in Canada (risk pathways with low stumpage variance)



Elimination of “Risk Premium” can Reduce Debt Costs by 100 – 400 Basis Points



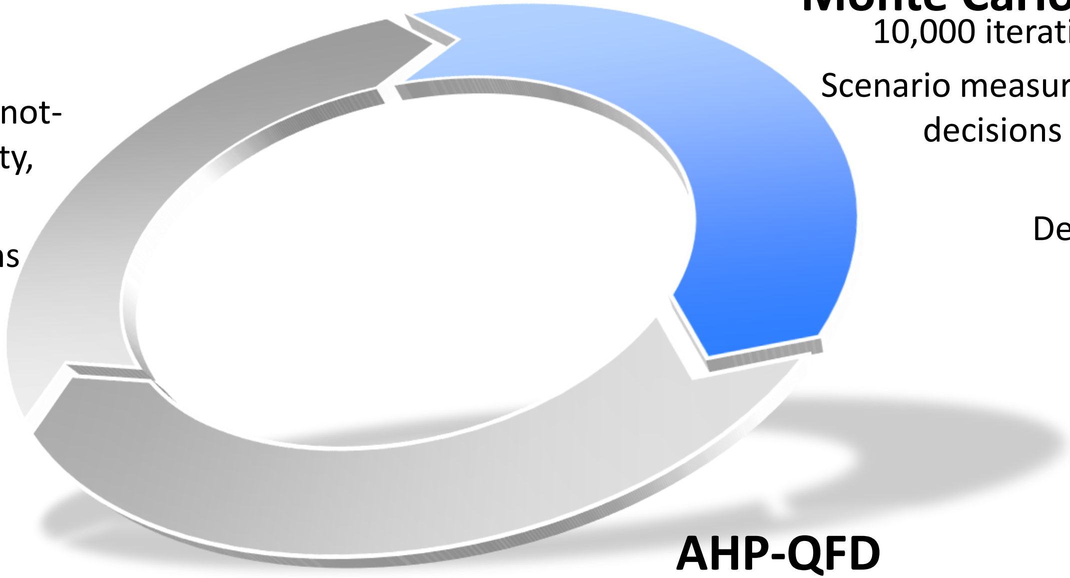
Ecostrat Biomass Supply Chain Predictive Analytics

Combined “Model-Layering” approach gives industry-leading predictive accuracy

Chance-Constrained Optimization

Feedstock constraints: 10 year not-to-exceed cost, feedstock quality, shortage.

Optimal management decisions regarding feedstock



Monte Carlo Validation

10,000 iterations per variable

Scenario measurement of supply decisions against projects constraints

Decision validation

AHP-QFD

Identificaton of suppliers, feedstock avialability, capacity, quality criteria, price.

Supplier Performence Score

The Impact of More Accurate Modeling of Supply Chain Risk

1. Increase the credit rating of bioenergy projects
2. Enable better pricing of risk by commercial lenders and debt providers
3. Decrease financial drag on bioenergy/ lower debt and capital cost

The Bottom Line:

Accelerate the rate of bioenergy project development in Canada

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People will not pay for value they do not perceive– no matter how real it may be.

Michael E Porter

To discuss your project please contact us

Jordan Solomon

Managing Director & CEO

Ecostrat Inc.

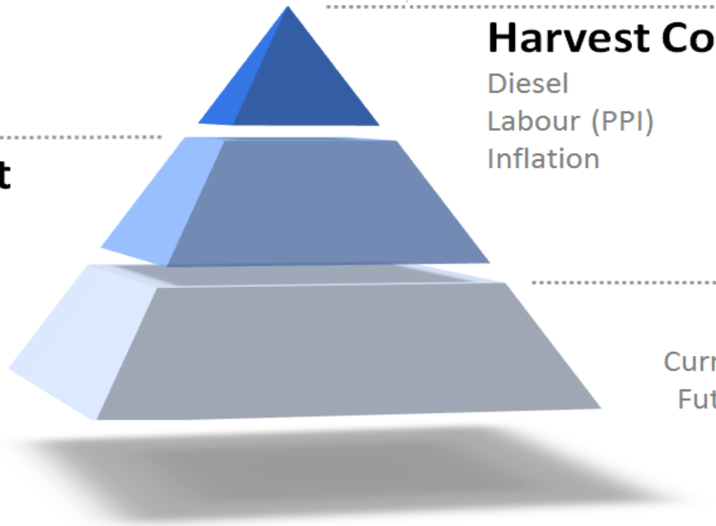
www.ecostrat.com

jordan.solomon@ecostrat.com

Tel: 416-968-8884 x 222

The 3 Components of Woody Biomass Supply Chain Cost/Risk

Main Risk Factors Causing Price Uncertainty Pertain to Stumpage



Harvest Cost
- Diesel
- Labour (PPI)
- Inflation

Transport Cost
- Diesel
- Labour (PPI)
- Inflation
- Trucking Distance

Stumpage Cost
- Current Demand /Competition
- Future Demand /Competition
- Indirect Demand
- Weather Events
- Land ownership
- Species
- Form Class
- US Housing
- Forest Inventory Rules
- Producer - Owner Relationship