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UNDER THE HOOD WITH FINITE CARBON: CHALLENGES AND SOLUTIONS IN FOREST CARBON MODELING

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ABOUT FINITE CARBON

FiniteCarbon

Finite Carbon is North America's leading developer and supplier of forest carbon offsets.

- Founded in 2009
- 60+ carbon projects Developed in the U.S. and Canada covering > 4 million acres
- Specialization in Improved Forest Management (IFM) projects developed under California Air Resource Board Compliance Offset Protocol for U.S. Forest Projects and ACR Voluntary methodologies
- Scope includes tribes, land trusts, TIMOs, REITs, forest products companies, and private forest owners with >= 40 acres
- My role: forest carbon quantification and modeling

100+

MILLION OFFSETS ISSUED

$1B

CLIENT REVENUE GENERATED

TARGET AUDIENCE, FOCUS, AND OVERVIEW

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- AUDIENCE:
  1) Those interested in bringing carbon project development program in-house, specifically with a focus on technical requirements
  2) Those currently doing carbon projects in-house, to provide some external developer perspective for you, and some feedback for me.
- FOCUS: Quantification and Modeling of CARB Compliance and ACR Voluntary Improved Forest Management projects. *Verification-centric*
- OVERVIEW:
  1) IFM Carbon Project Development Basics
  2) Quantification Considerations
  3) Baseline Modeling Considerations

1. IFM CARBON PROJECT DEVELOPMENT OVERVIEW

INITIAL CARBON PROJECT DEVELOPMENT LIFECYCLE

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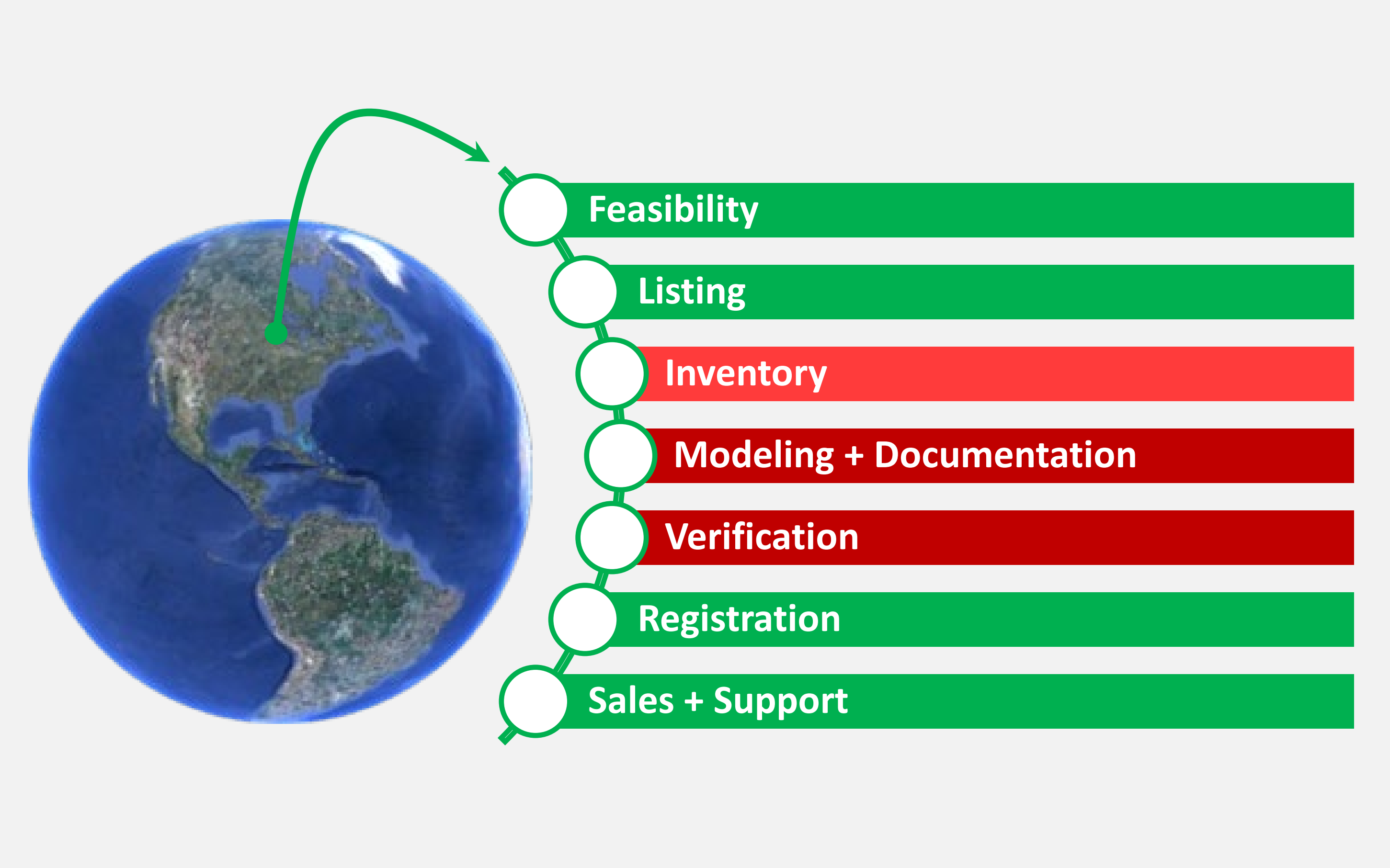
12 – 24 Month Issuance Timeline From Inventory Collection

- Modeling + documentation can take 2 to 6 months internally
    - Inventory analysis
    - GIS work
    - Property due diligence
    - Baseline modeling
    - Client-led revisions and scenario analysi
- Verification typically lasts **6 to 18 months**
- Subsequent RPs take less time



MULTIPLE LAYERS OF SCRUTINY

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- **Verifiers:** Independent third-party entities that assess and validate project design, methodologies, and reported emission reductions or removals, ensuring that forest carbon projects meet the chosen protocol's requirements and that credits issued are real, additional, and accurately quantified.
  - Examples: SCS Global, S&A Carbon, Tuv Sud
- **Registries:** Organizations that maintain the official project registry, issue and track unique serial numbers for verified carbon credits, manage credit retirement and transfer, and publicly report project and crediting information to ensure transparency and prevent double counting. Conducts additional reviews for template adherence, grammar, and, sometimes, project design and quantification.
  - Examples: ACR, Climate Action Reserve, Verra
- **California Air Resources Board (CARB or ARB):** Accredits and oversees verification bodies and offset verifiers under its Compliance Offset Program, requires submission and review of Offset Verification Statements, including potential full, second review of all materials submitted for verification.

100% Error Free Is The Expectation!

2. QUANTIFICATION CONSIDERATIONS

HOW MUCH CARBON IS IN THOSE TREES?

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- A: Depends on what the meaning of the word "is" is…

	USFS FIA CARBON ACCOUNTING*		CARBON ACCOUNTING* USED IN PROTOCOLS				
	FIA NVEL (Legacy)	FIA NSVB (post 2023)	ARB Lower 45	ARB OR WA CA	ARB AK	Jenkins 2003	FVS-FFE
Carbon Creation Path	Volume-> Biomass-> Carbon	Volume-> Biomass-> Carbon	Volume-> Biomass-> Carbon	Volume-> Biomass-> Carbon	Biomass->Carbon	Biomass->Carbon	Volume-> Biomass-> Carbon
Volume Method	Multiple regional model forms	Limited and consistent number of model forms	Woodall et al. (2011) CRM	2014 FIA Document	N/A	N/A	Multiple, modifiable regional model forms
Biomass Method	Woodall et al. (2011) CRM	New empirical models	Woodall et al. (2011) CRM	2014 FIA Document	2014 FIA Document	Species-group dependent	Multiple regional allometric equations
Reported in FVS	Yes	Forthcoming	No	No	No	Yes	Yes
Tree-level detail	Yes	Yes	Yes	Yes	Yes	Sort of	FIA NVEL: No; FIA NSVB: Yes, but SLAG only
ARB Compliance (Y/N)	N/A	N/A	Y	Y	Y	N	N
ACR Voluntary (Y/N)	N/A	N/A	Y	Y	Y	Y	Y

*This chart considers live trees only

ARB ≠ FVS FFE

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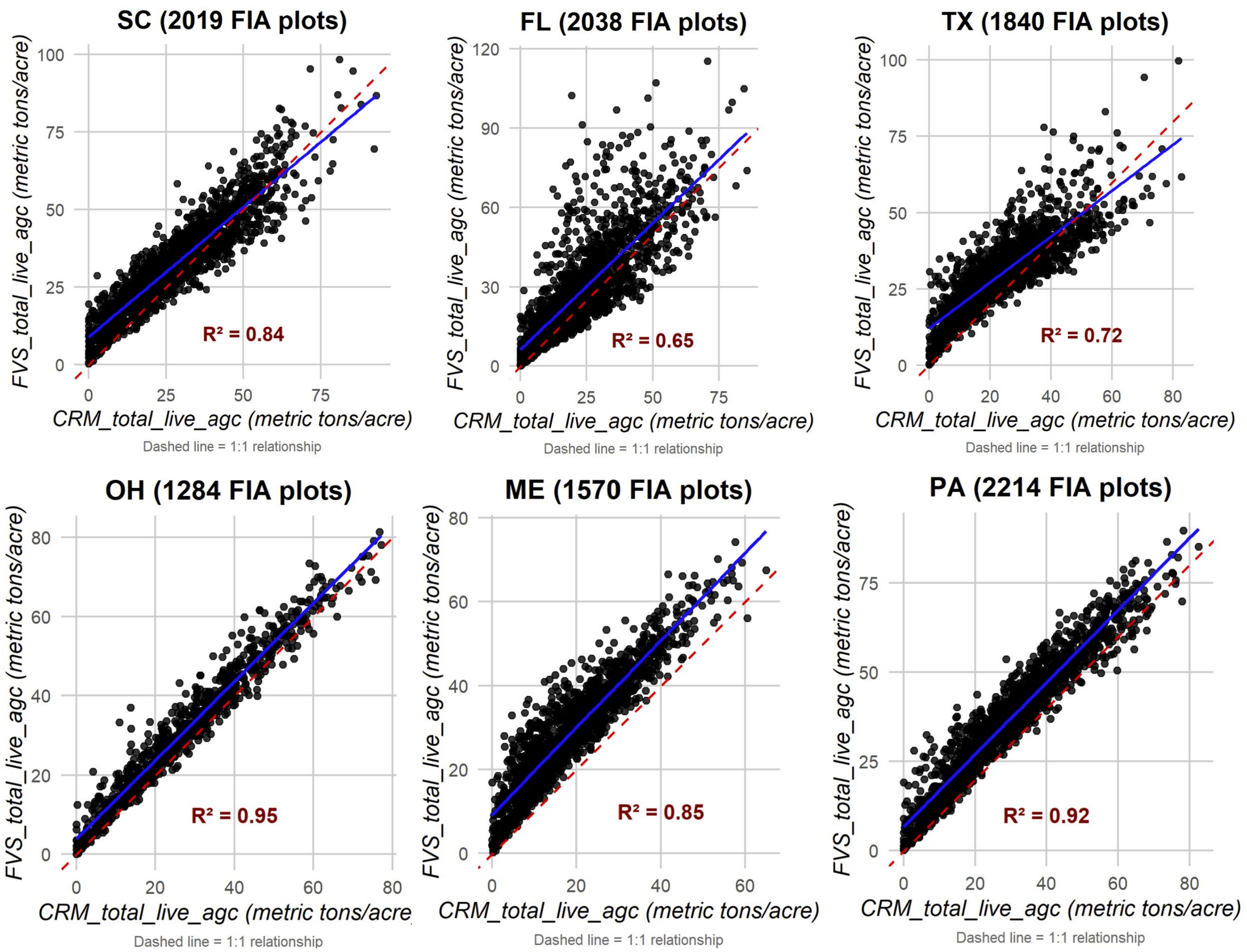

FIA ≠ FIA

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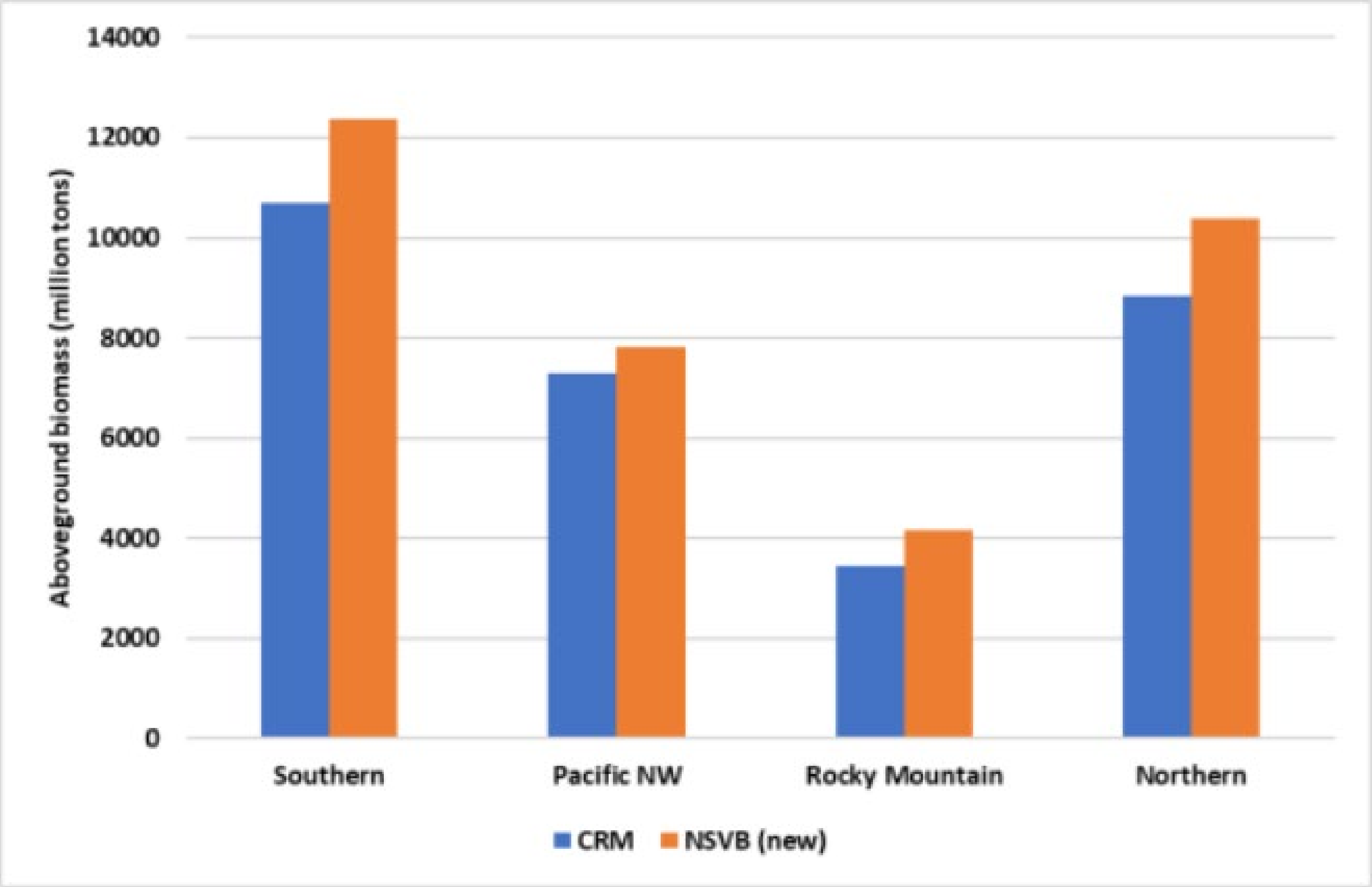

Note: ACR 2.1 Methodology allows implementation of NSVB or NVEL (CRM) methods!

QUANTIFICATION MIXING AND MATCHING

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Protocol / Methodology	Resolution	AG Live Carbon	BG Live Carbon	Standing Dead Carbon
ARB Forest Offset Protocol (2014 and above)	Individual tree-level, species specific	**OR, WA, CA:** 2014 FIA documents for volume and biomass equations **AK:** 2014 FIA document equations for biomass only. **All Other States:** Woodall et al (2011) volume equations and CRM methods for tree components (Heath 2009)	**OR, WA, CA, AK:** No guidance given; Cairns et al. (1997) commonly used. **All Other States:** CRM	Domke (2011) SLA Factors for **5** decay classes with Harmon (2011) DRF factors
ACR 1.3	Individual tree-level, species specific or plot total	1. Generalized allometric equations 10 species groups (Jenkins et al. 2003). *Plot-level* 2. FVS – FFE. *Plot-level* 3. ARB FOP Methods. *Tree-level*	1. Generalized allometric equations 10 species groups (Jenkins et al. 2003). *Plot-level* 2. FVS – FFE. *Plot-level* 3. ARB FOP Methods. *Tree-level*	1. IPCC (2006) method – **4** decay classes 2. FVS-FFE (does not include stump or bark)
ACR 2.0 and above	Individual tree-level, species specific or plot total	1. Generalized allometric equations 10 species groups (Jenkins et al. 2003). *Plot-level* 2. FVS – FFE. *Plot-level* 3. ARB FOP methods. *Tree-level*	1. Generalized allometric equations 10 species groups (Jenkins et al. 2003). *Plot-level* 2. FVS – FFE. *Plot-level* 3. ARB FOP methods. *Tree-level*	1. Domke (2011) SLA Factors for **5** decay classes with Harmon (2011) DRF factors 2. FVS-FFE

QUANTIFICATION RECOMMENDATIONS

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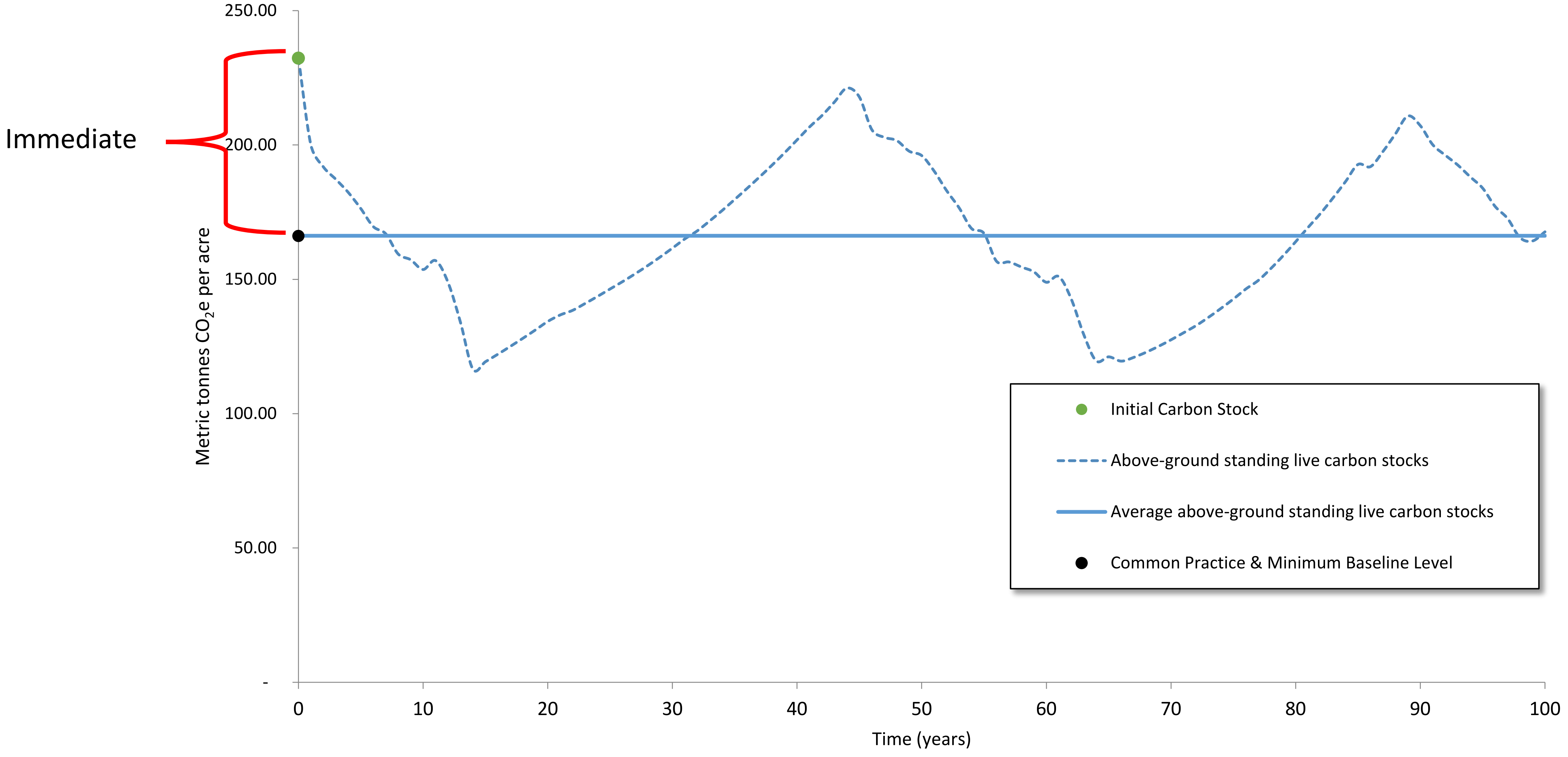
- Error Tolerances Before Something Bad Happens In A Carbon Project
  - Check cruising: ~10%
  - Standard Error / Uncertainty: 10%
  - Field measured t-test: 10% (e.g. 90% CI)
  - Calculation errors: **0%**
- Implications And Recommendations For Successful Verification
  - Simpler is better: Use FVS-FFE outputs if only doing voluntary projects
  - The feds are always right: when in doubt, lean on USFS tools, methods, and publications
  - If doing CARB projects, build your systems around CARB quantification methods – works everywhere
  - Help your verifiers and yourself by building re-calculation example tools
    - *Everyone knows Excel!*

3. BASELINE MODELING CONSIDERATIONS

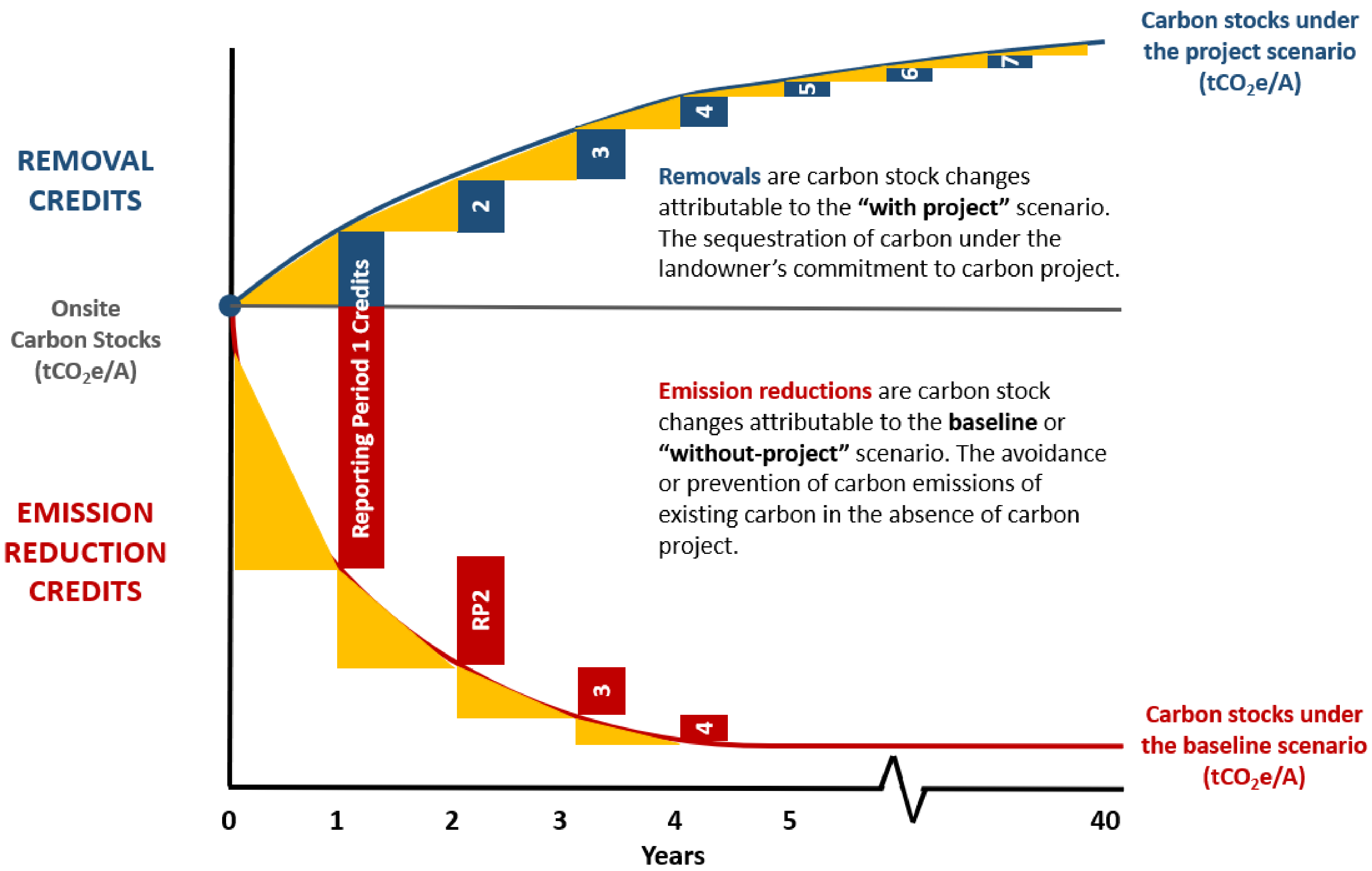
BASELINE BASICS

- Simulated harvest schedule and associated carbon stocks of a “business as usual” timber production strategy, *e.g.* the counterfactual, hypothetical scenario that would happen in the absence of a carbon project.
- Must be legally, operationally, and financially feasible
- Modeled on a 100-year basis (regardless of crediting period)
- Typically modeled with harvest scheduling software, *e.g.* Remsoft
- **Must be verifiable**

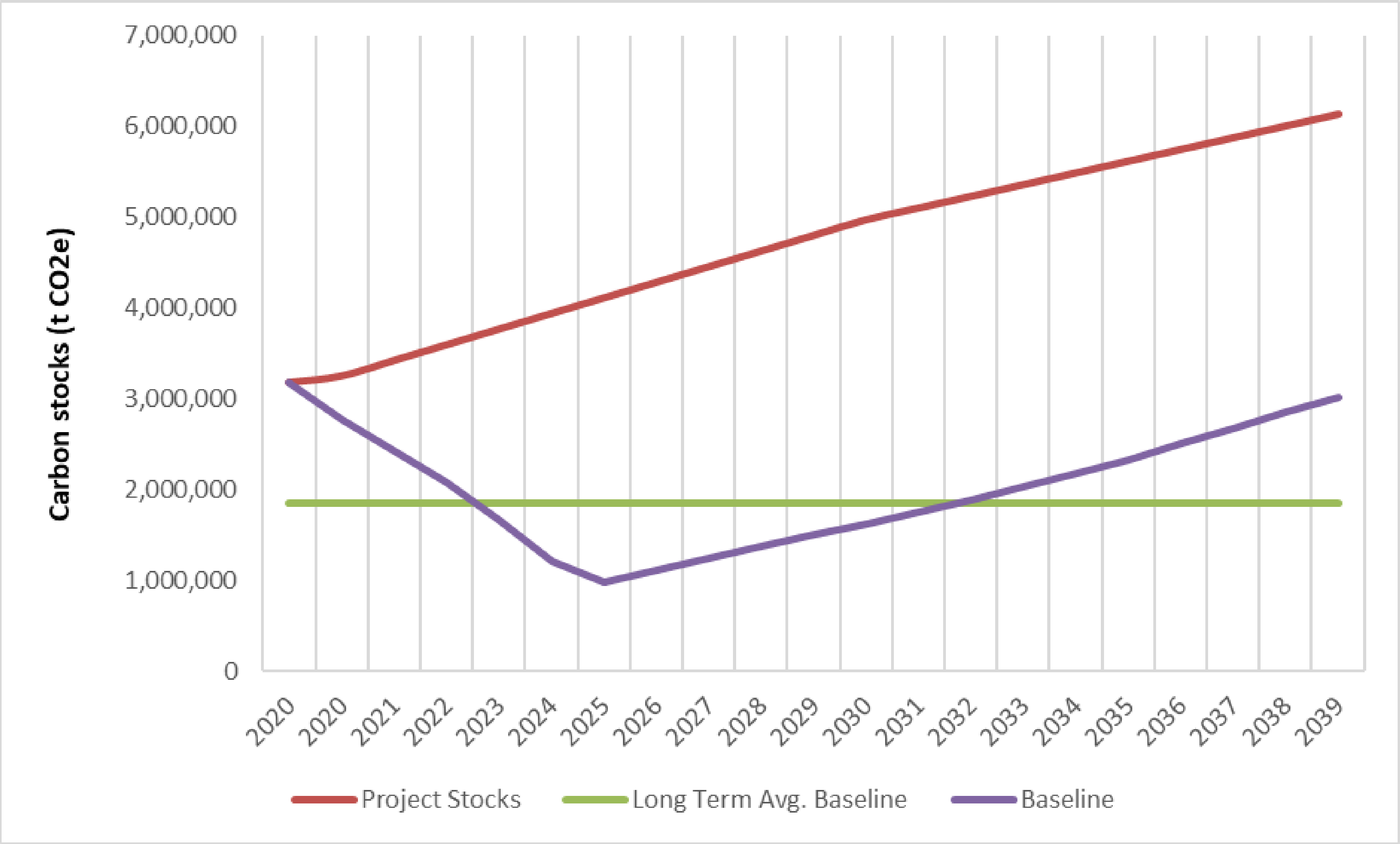
ARB IFM Project Crediting



ACR IFM Project Additionality and Crediting



ACR IFM Project 20-Year Average Baseline



BASELINE DETAILS: BEHIND THE CURTAIN

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Every carbon project baseline developed requires a management planning effort equivalent to constructing an investment-grade forest estate model. At least.

- *GIS (ownership,legal,stratification,operational etc.)*
- *Inventory*
- *Silviculture*
- *Growth and Yield*
- *Operational costs and logistics*
- *Timber economics (pricing, merchandising, and destination)*
- *Legal*
- *Other harvest constraints*

"EVERY BASELINE IS A COMPREHENSIVE FOREST MANAGEMENT PLAN"
- B. SHARER, CIRCA 2020

BASELINE REPLICABILITY: CAN THE VERIFIER RE-CREATE?

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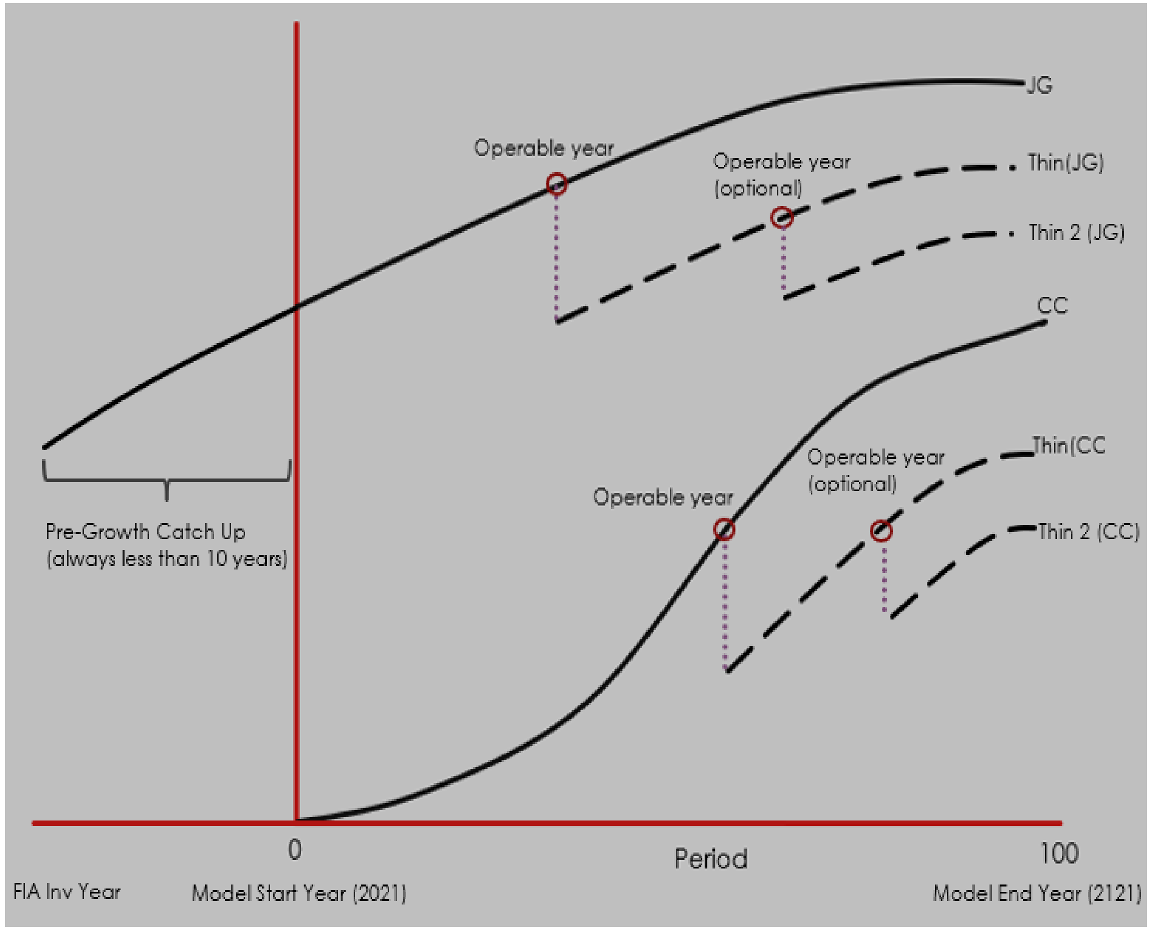
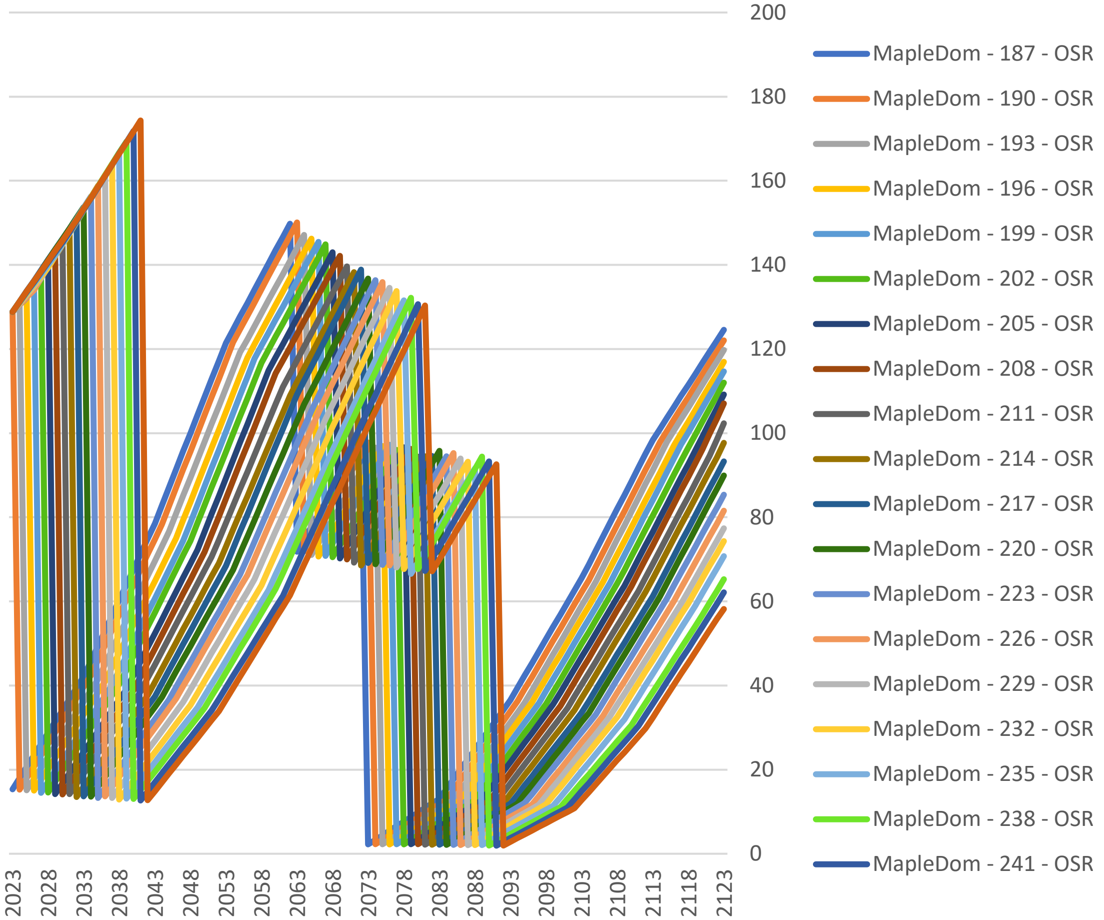
Typical "Model 2" LP Yields: Difficult to Recalculate



Model 1 Yields: Acres assigned to FVS Rx: Easy To Recreate



EXAMPLE BASELINE MODEL 1 HARVEST SCHEDULE

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STEPS TO VERIFY, IF YOU'RE THE VERIFIER

1. Run each yield curve's (YC) keywords in FVS
2. Grab the FVS tree lists and cut lists from each YC
3. Calculate the carbon from the 100-year tree lists and cut lists
4. Multiply the acres assigned to each YC times the carbon outputs.
5. Voila! The baseline is re-created, without having to use Remsoft!

Strata	Operability	Silviculture System	YC	Area Assigned	SLAG	IFM1	IFM3	TotOCS
LH	UPLAND	Grow Only	1	567.10	224.79	268.03	15.97	284.00
LH	UPLAND	Clearcut	33	1785.65	95.05	113.60	2.86	116.46
LH	UPLAND	Clearcut	37	1731.48	100.77	120.40	3.13	123.53
LH	UPLAND	Clearcut	41	1689.69	106.57	127.31	3.55	130.86
LH	UPLAND	Light Thin	149	104.57	66.61	79.81	0.86	80.68
LH	UPLAND	Light Thin	153	2500.00	68.03	81.50	0.92	82.42
LH	UPLAND	Light Thin	157	2500.00	68.90	82.54	0.94	83.48
LH	UPLAND	Light Thin	161	749.70	70.00	83.85	0.99	84.84
LH	SMZ	Light Thin	149	498.05	66.61	79.81	0.86	80.68
LSO	UPLAND	Light Thin	142	1337.93	53.46	64.30	0.74	65.04
LSO	UPLAND	Light Thin	146	2500.00	56.78	68.27	0.84	69.11
LSO	SMZ	Light Thin	142	153.78	53.46	64.30	0.74	65.04
OH	UPLAND	Light Thin	163	1698.22	98.79	118.12	1.29	119.41
OH	SMZ	Light Thin	163	52.08	98.79	118.12	1.29	119.41
UH	UPLAND	Clearcut + Heavy Thin	52	1122.38	45.95	55.01	0.94	55.95
UH	UPLAND	Clearcut + Heavy Thin	72	2500.00	46.62	55.83	0.95	56.78
UH	SMZ	Grow Only	4	118.59	183.72	219.15	15.32	234.47
			Total	**21,609.2**	1,671,257.9	2,000,103.6	42,234.8	2,042,338.4
			Per Acre		77.34	92.56	1.95	94.51

BASELINE RECOMMENDATIONS

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1. Spend the time necessary to review all relevant property details and data.
2. Check, check, and re-check your GIS workup
3. Check, check, and re-check your yield curves.
   A. Inspect results visually
   B. Scan your FVS .OUT files
4. Use a process that can be re-created independently. Make tools. *Everyone knows Excel!*
5. Keep in mind that baseline re-models add weeks of time to verification timelines; there are many ways to get it wrong, and only 1 way to get it right!

QUESTIONS