Final Report

Stand Response to Thinning:

Enhancing Response Prediction Through Modeling

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Justification

- Forecasting yield is a primary objective of forest managers
- Thinning a stand has a propensity to alter stand allometry
- Stand productivity:

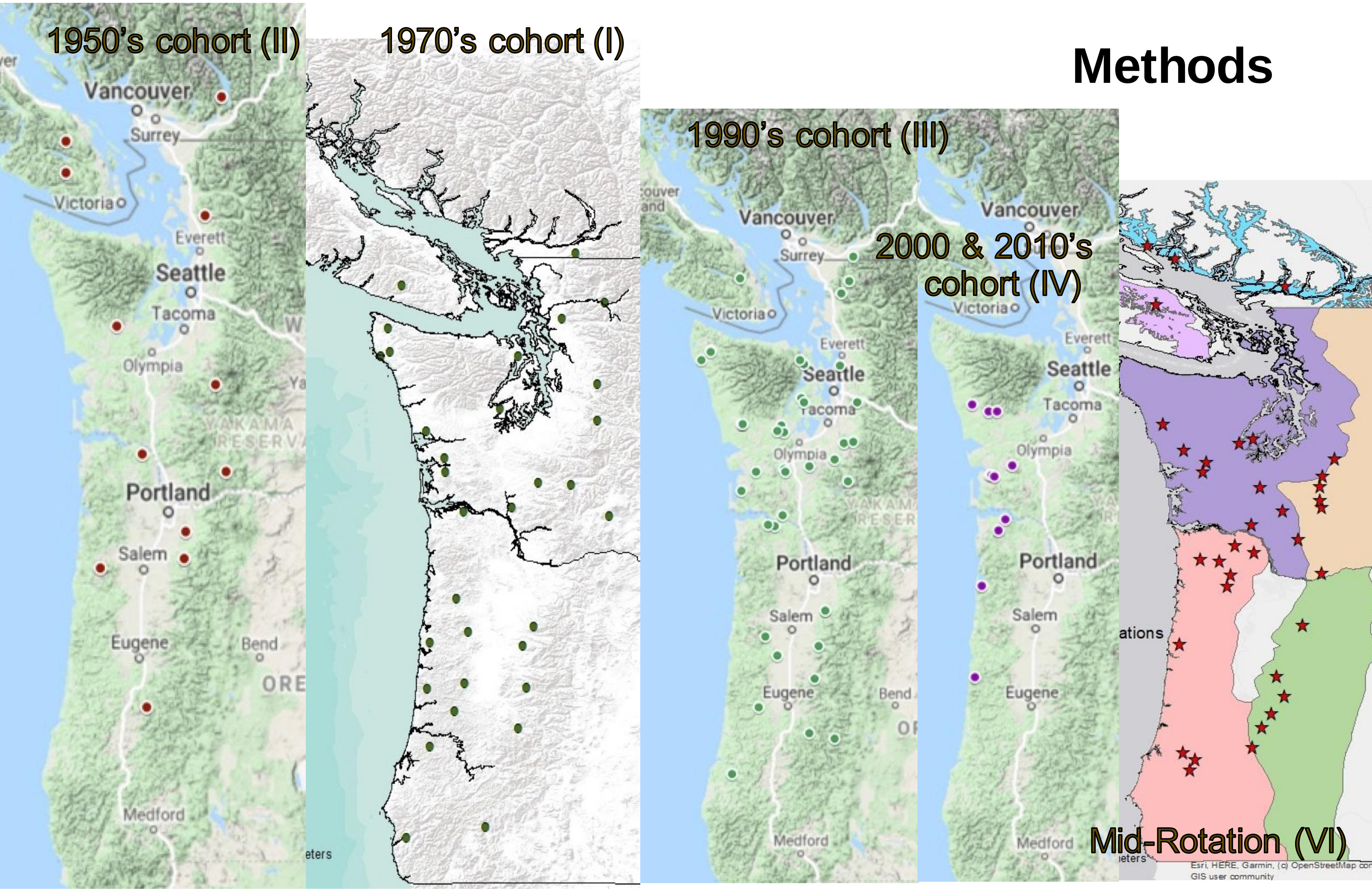
  Actual → *Realistic [Realizable?]* → *Potential*

- Decision space is clearly in zone between Actual and *Potential*

Hypotheses or Objectives

- Refit the extant base stand yield model (untreated stands) within the SMC Plantation Yield Calculator (SMC-PYC) given another two full cycles of data collection, improved volume estimates, and updated physiographic region data
    - Predict crop & total yields:
        - Trees per Acre (TPA), Basal Area (BA), Quadratic Mean Diameter (QMD)*, Cubic-foot volume including top (CVT), Cubic-foot volume to a 4” top (CV4), to a 6” top (CV6), Board-foot volume to a 4” top (BF4), to a 6” top (BF6)
- Fit a survival model mortality to order to back-calculate planting density and calculate actual PCT intensity, also to derive QMD from TPA and BAA
- Incorporate Pre-commercial and Commercial Thinning effects using results of Cross & Turnblom (2020); where a thinning is defined by its timing (PCT = absolute, CT = relative) and intensity (proportion of stems removed)

Methods


1950's cohort (II)
1970's cohort (I)
1990's cohort (III)
2000 & 2010's cohort (IV)
Mid-Rotation (VI)
Esri, HERE, Garmin, (c) OpenStreetMap
GIS user community

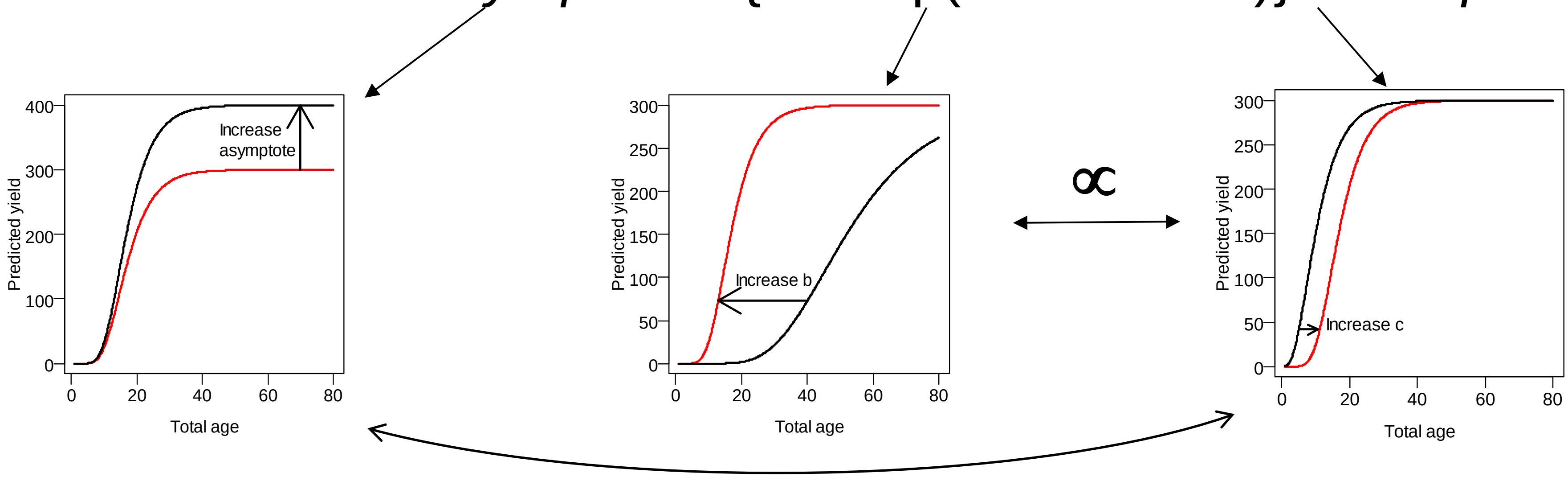
Methods

- The base modeling framework selected for the Stand Management Cooperative-Plantation Yield Calculator (SMC-PYC) is the Richards (1959) function for its quasi-biologically interpretable parameters

- Use a standard algorithm for implementing weighted least squares to identify system parameters, coupled with a bootstrapping step to examine parameter distributions for eliminating those that are statistically not significant (0.10 error rate) [Objective 1]

Methods

Functional Form: *asymptote* * {1 – exp(-*rate* * AGE)} ** *shape*



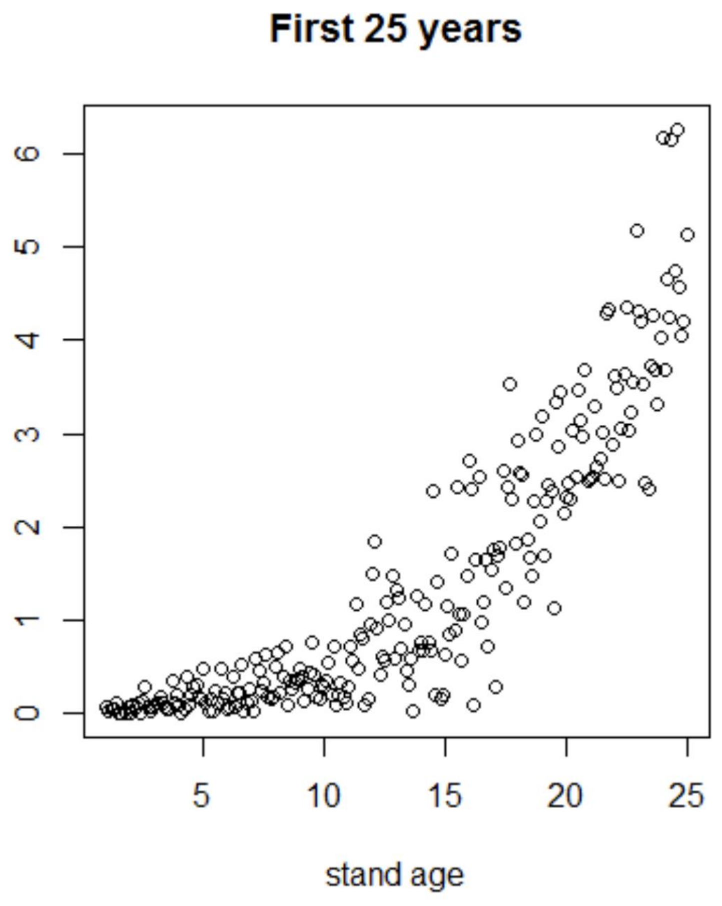
asymptote, *rate*, *shape* ~ f(Planting density*, site index*, species (PSME, TSHE, Mixed), location, elevation, climate, soils, latitude, longitude, PCT effect*.)

1. Fit using Nelder-Mead method
2. Bootstrap to eliminate non-significant predictors

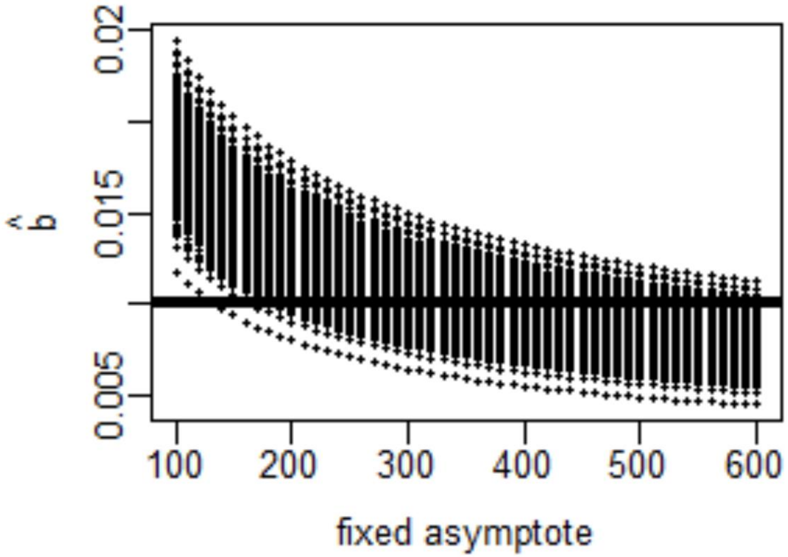
Methods

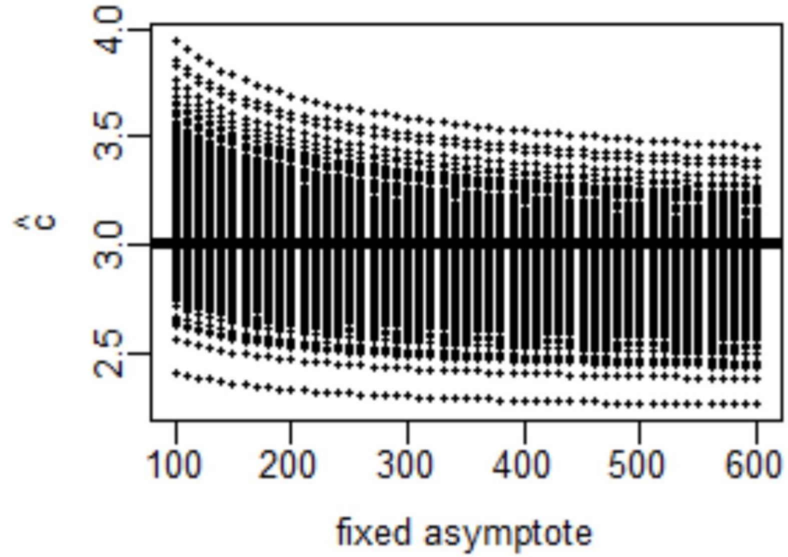
Simulation study

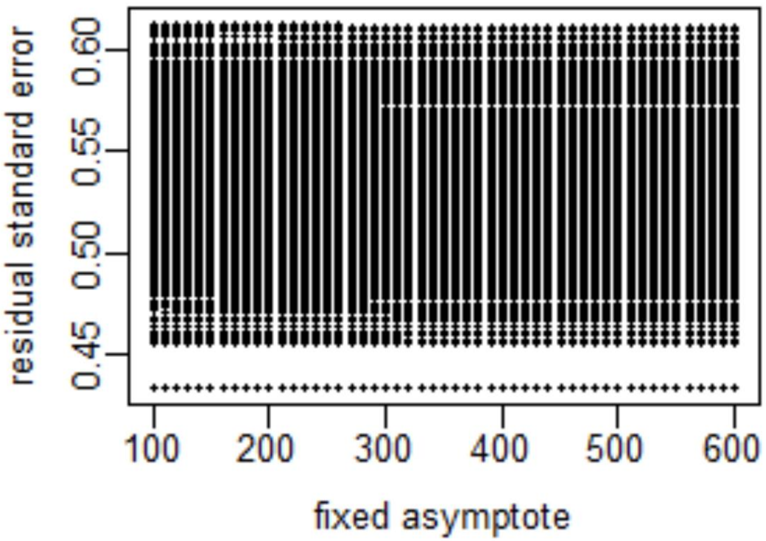
- Set values for all C-R coefficients: a = 400, b = 0.01, c = 3
- Simulate over-dispersed errors, weighting by age/age_max
- Simulate data for ages (1:400)
- Retain only first 25 years
- Iterate over values of the asymptote (a), ranging from 100 – 600, by 10
- Fit curve to first 25 years of sim data, retain values of coefficients (b, c) and predicted yield



Methods







Simulation study - Results

- Horizontal lines at true values of b and c
- Residual std. error is insensitive to the fixed asymptote (a)
- coefficient estimates (b, c) are sensitive (as expected)

Major Findings

- Fixing the Chapman-Richards asymptote parameter to scientifically supportable values (based on site productivity – as in Bulletin 201) is much better than trying to fit them

- The mortality model [Objective 2 – Completed] still has two regions (classification) variables remaining in the model

- Refined planting density estimates (survival @ 3y) remains a key to differentiating between treatment yields

Deliverables

- Further updates on PYC modeling
  - Version 2.0 : Baseline Equations
  - Version 2.1 : Version 2.0 + PCT effect
  - Version 2.2 : Version 2.1 + CT effect
- Working Paper to be delivered to SMC membership detailing data, methods, and results
- User interface to yield model available to SMC membership (SMC-PYC v.2)

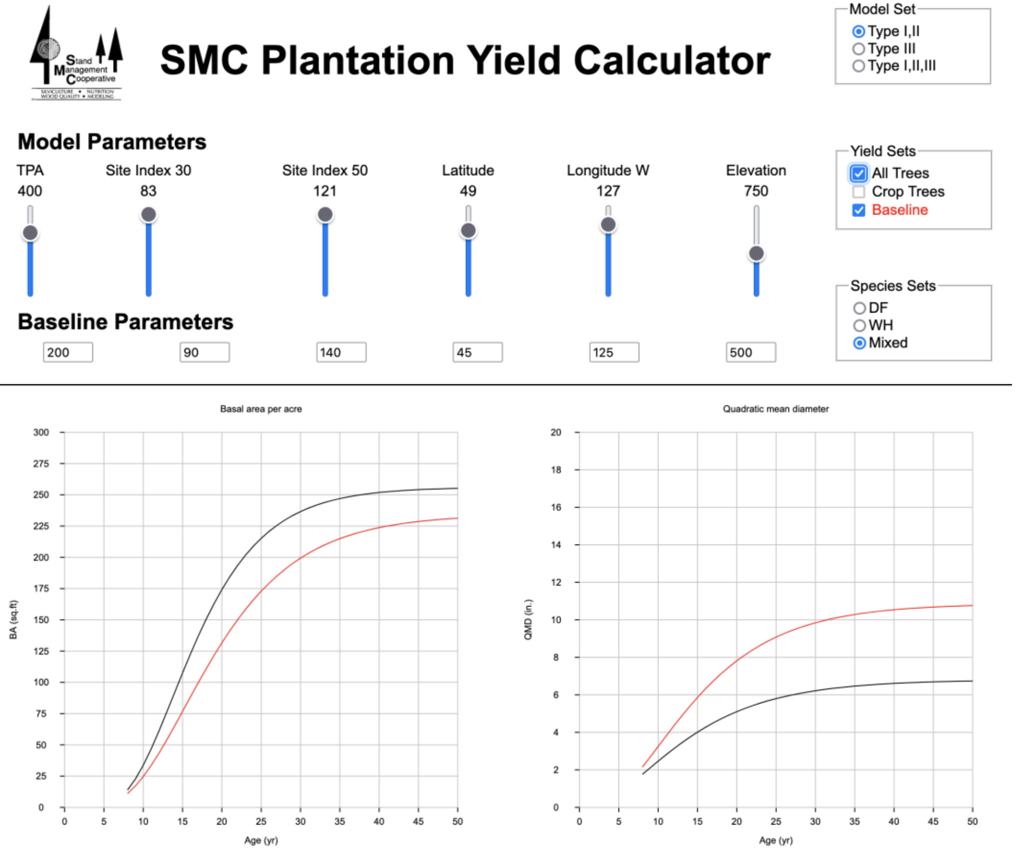
Basal Area (sq.ft./acre)

	Planted	Stems	Per	Acre	
AGE	100	300	500	700	900
3	0.0	0.0	0.1	0.1	0.2
5	0.1	0.3	0.6	1.2	2.0
10	2.5	5.5	10.5	17.6	26.5
15	12.3	23.9	40.7	60.7	82.2
20	33.7	58.1	88.7	119.8	148.4
25	67.2	104.0	144.1	179.2	206.8
30	110.4	154.8	197.6	229.7	250.9

QMD (inches)

	Planted	Stems	Per	Acre	
AGE	100	300	500	700	900
3	0.2	0.1	0.2	0.2	0.2
5	0.5	0.4	0.5	0.6	0.6
10	2.2	1.8	2.0	2.1	2.3
15	4.9	3.9	3.9	4.1	4.2
20	8.2	6.2	5.9	5.9	5.9
25	11.7	8.4	7.8	7.5	7.3
30	15.2	10.5	9.4	8.8	8.3

Company Benefits



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Age	BA	QMD	TPA	BF4	BF6
5	0	0.5	272	0	0
10	6	1.9	295	0	0
15	25	4.0	293	674	5
20	61	6.3	282	3654	1046
25	108	8.6	270	8155	5786
30	160	10.7	257	13617	14700

- Project results would be a standardized framework for stand modeling
- Easier future calibrations of growth and yield prediction models given framework for model updates
- Mortality, Planting Density, QMD yield models can be applied directly to FVS to grow & generate tree lists that match yield metrics
- Improved forest planning and financial assessments

Recommendations

- Parameter prediction method is quite useful, particularly when parameters and their predictors are identified simultaneously, after the sensitive parameters have been identified

- “Winnowing” down the field of potential parameter predictor variables using principal components is very useful (especially when pool is large)

- Investigation of the mechanisms behind the differences in physiographic regions and their local climate effects is useful

- Keep opportunities for cross-region collaboration open

Summary

- The PCT database was folded into the complete, well formatted PYC database
- Short trip on a side rail for this train was taken to evaluate the sensitivity of the C-R coefficients (a, b, c)
- Updated model fitting process underway to incorporate climate effects
- Independent data set has been identified for benchmarking
- Public presentation(s) of findings at CAFS Semi-Annual IAB Meetings and Regional Research Meetings