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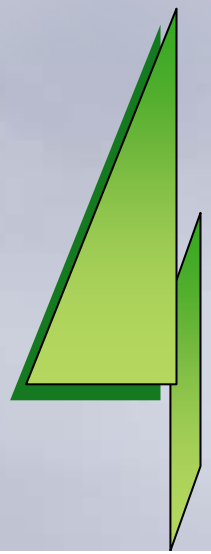
World-Class Natural Resource Decision Support

Eric Cox
Planning Forester



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Planning Your Work, Working Your Plan

Eric Cox

2005 SAF NATIONAL CONVENTION

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Purpose of Study

To investigate whether divergence from planned activities can lead to problems in achieving harvest targets, compliance with spatial requirements arising from certification or state law and achieving desired returns from managing forest land (PNV).

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Why is this Important?

Investors using sophisticated models

- Highly detailed GIS and inventory information
- Biometric models now include silvicultural treatment responses
  - Intensive silviculture modeled
  - Directly represented rather than multipliers
- Push to optimization models
  - Many diverse alternatives included and optimal solution is selected
  - Need for spatially specific forest plans
- Users of these sophisticated techniques will achieve improved returns

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Why is this Important?

- **But … what if the field forestry staff don't implement the optimal plan**

- Some organizations still use historic 'rules of thumb' to guide implementation
- Some continue current harvesting practices
  - Even while silvicultural intensity is increasing
  - Even with greater input specificity, more detailed models
- Some follow the broadest intent of the plan
  - Using aggregated wood flow or cash flow information to guide implementation
- Some look at only the short term while allocating harvests spatially
  - With danger of "painting themselves in a corner"

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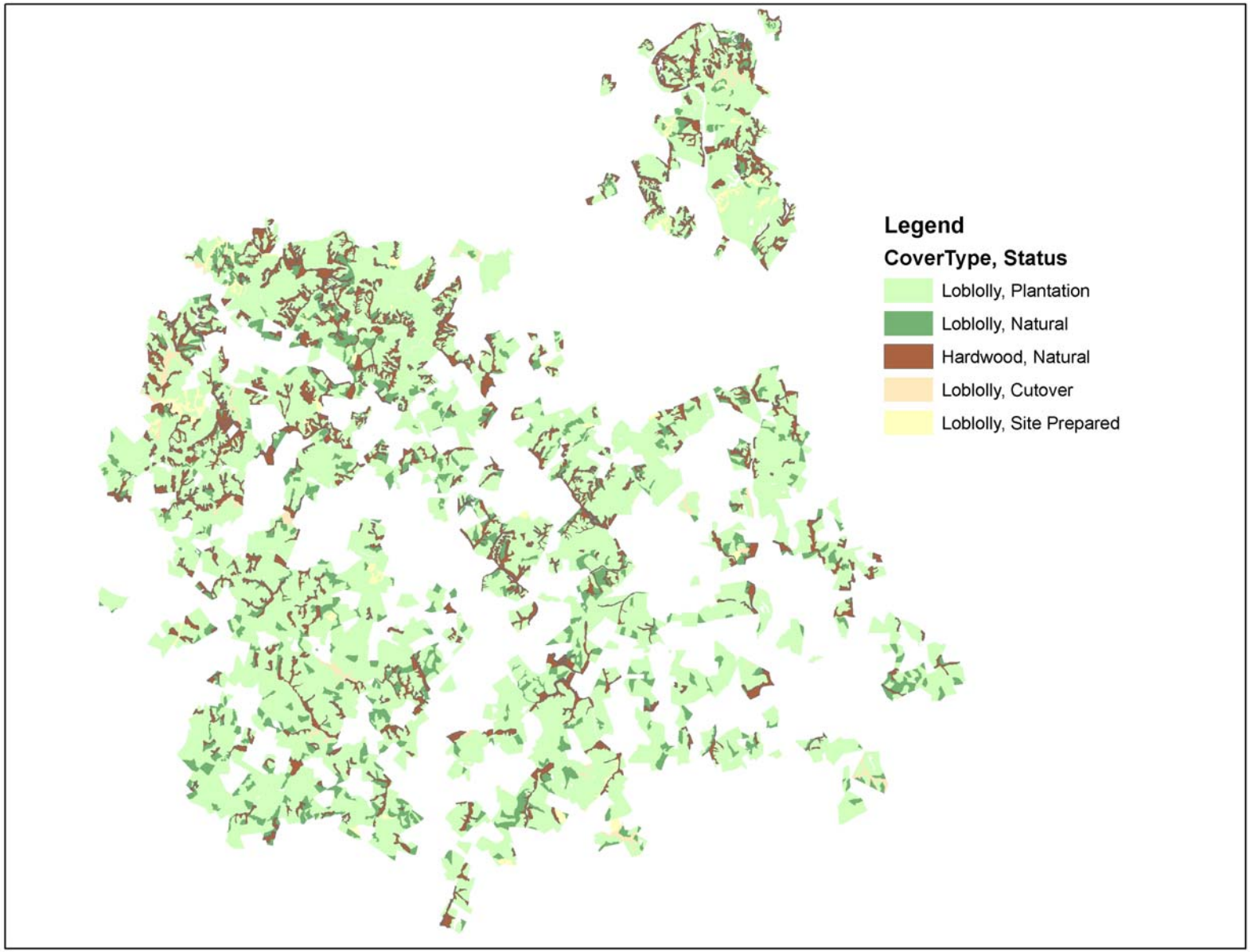
The Forest



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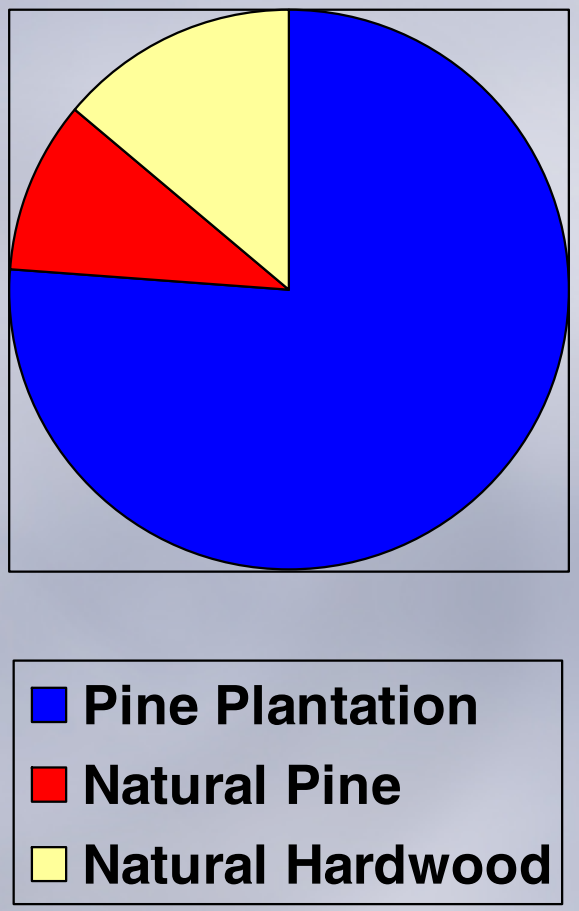
The Forest

- 159,000 acres
  - 588 strata
- Pine
  - Plantation 121,000 ac
  - Natural 16,000 ac
- Hardwood
  - Natural 22,000 ac



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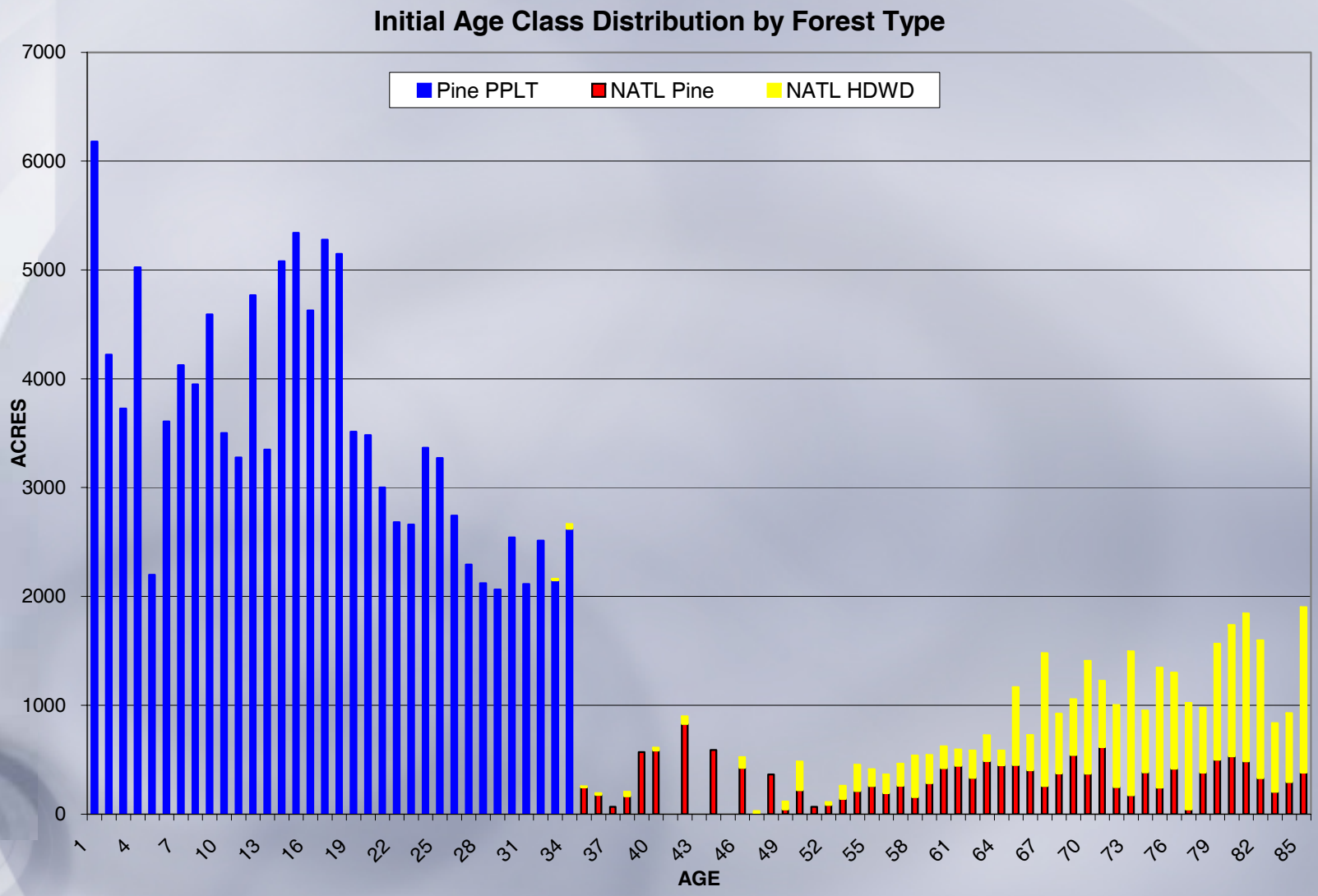

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The Model

- Even Age Management
- Silviculture
  - Fertilization regimes
    - Standard Regime – No early fertilization
    - Intensive Regime - Juvenile fertilization at age 5 and 10
  - No Thin Regime Includes Optional Mid-Rotation Fertilization
- Harvest Regimes
  - Thinning is Optional
    - All Thins Receive Post-Thin Fertilization
    - Thin Ages 14-20 (7 year window)
  - Final Harvest Ages 20+
- 8% Real Discount Rate (net of inflation)
- Before-Tax Analysis

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Base Model

- Objective Function
  - Maximize NPV
    - Model horizon 100 years
    - 1 Year Periods
  - Linear Programming-Based Model
    - Model II Formulation
- Constraints
  - Sequential Flow
    - +/- 20% on total pine volume harvested
  - Sequential Flow
    - +/- 20% on age 30+ acres clear cut years 1..8

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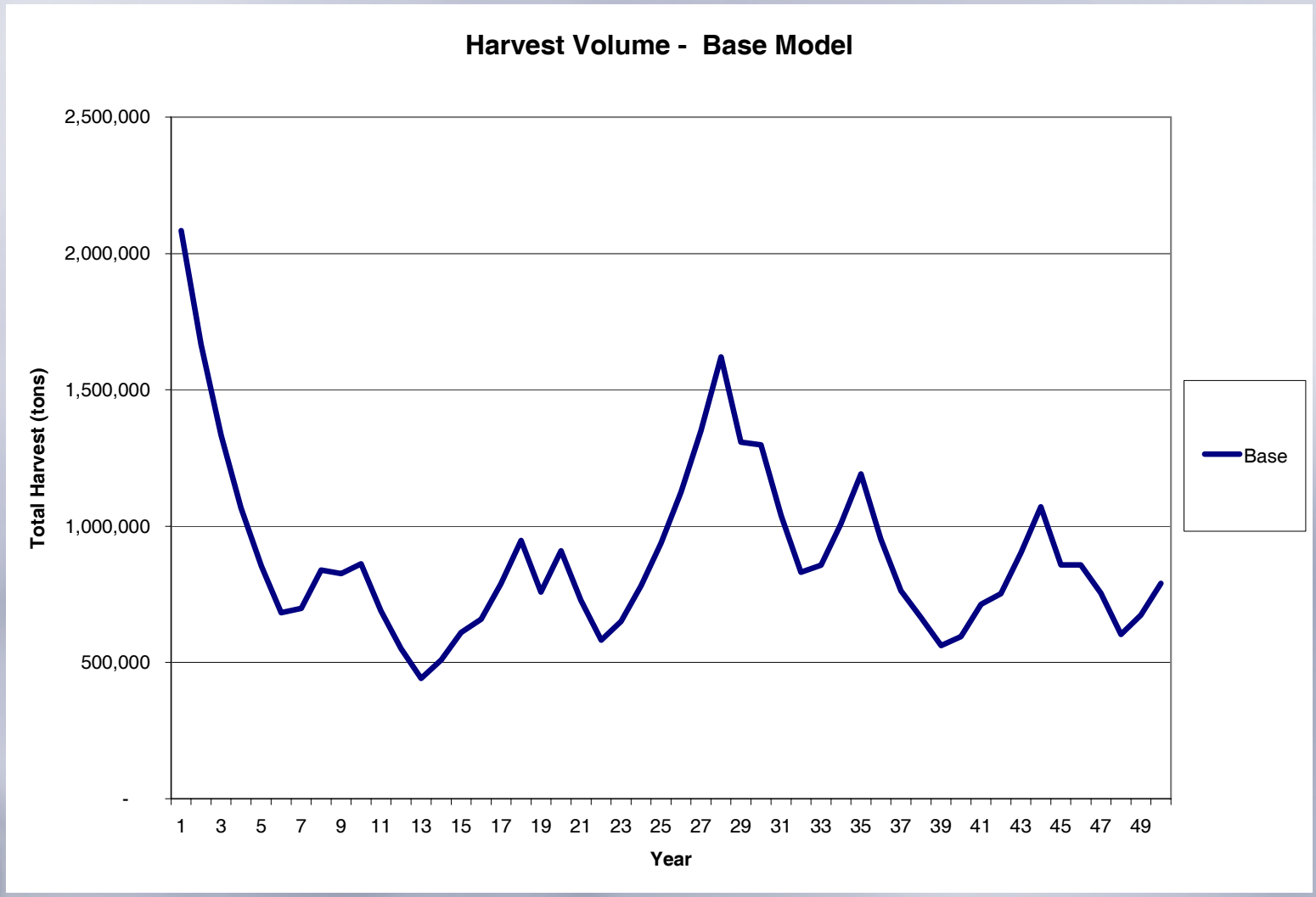
Base Model



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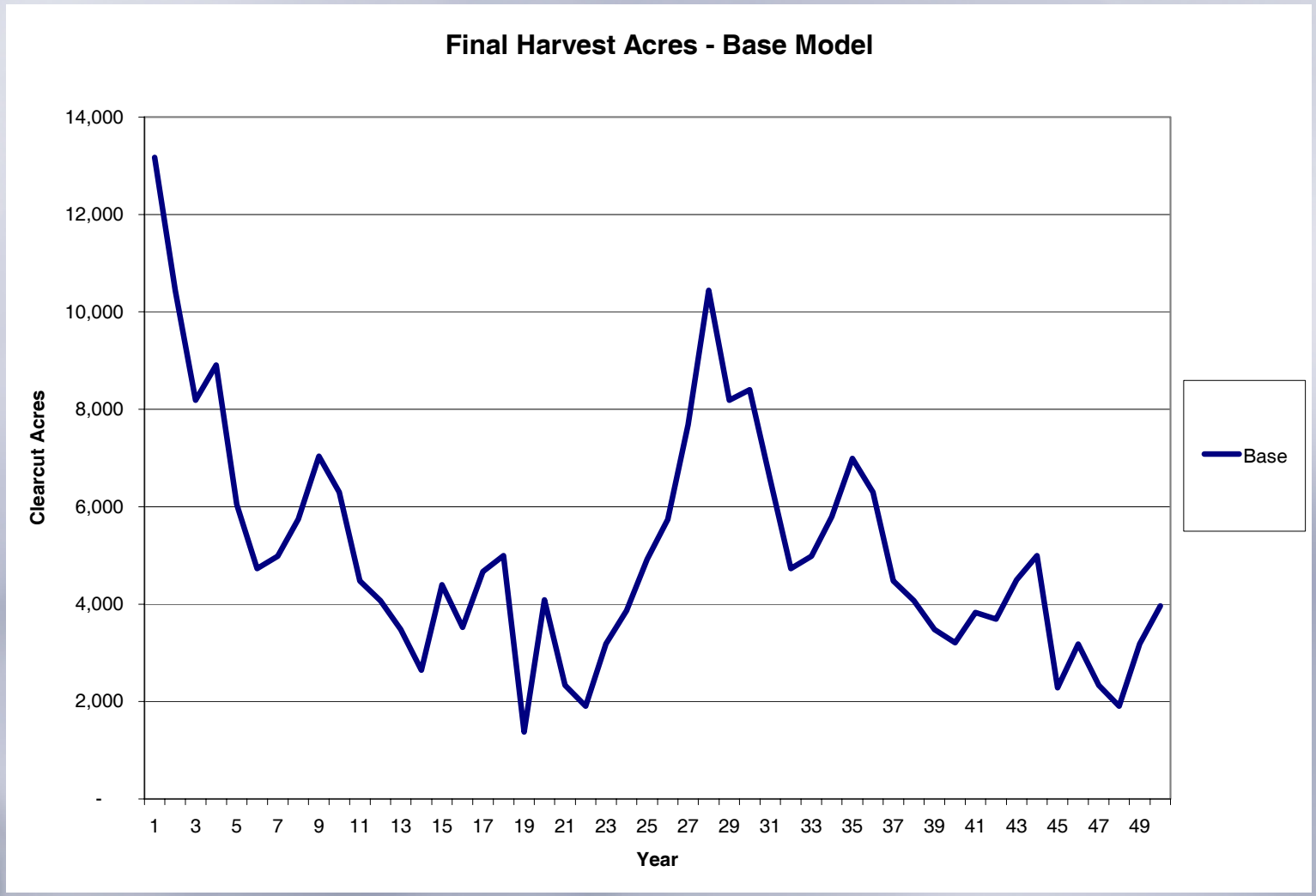
Base Model



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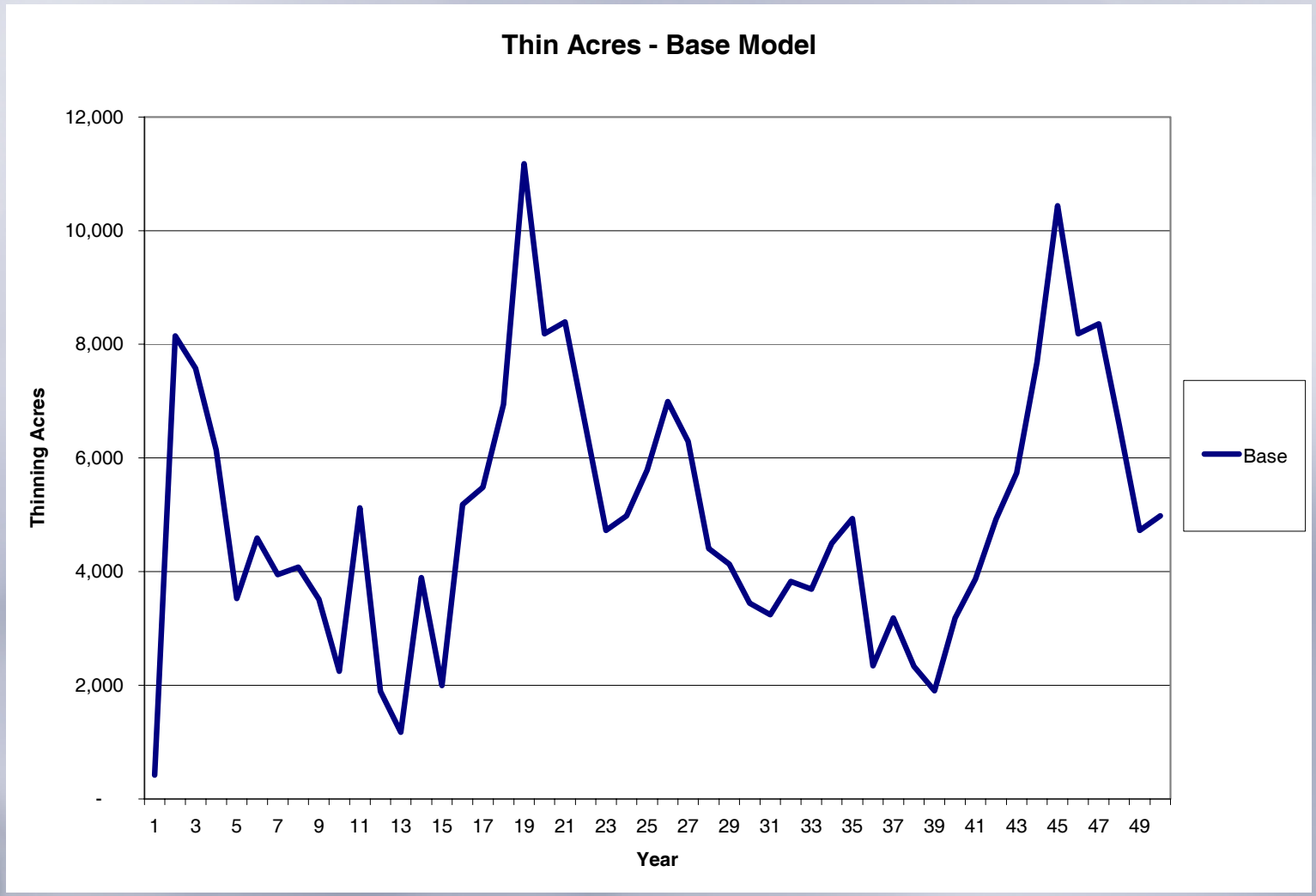
Base Model



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Spatial Alternatives

Parameters	Sp.Plan	Annual
Periods Blocked	1..10	1..1, 2..2, 3..3, …,9..9,10..10
Max Deviations (periods)	1	1
Objective	NPV	NPV
Min Block Size (acres)	20	20
Max Block Size (acres)	300	300
Target Block Size	none	none
Greenup Delay (periods)	3	3

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Results

What is the impact of not following the harvest pattern suggested by sophisticated spatial allocation tools?

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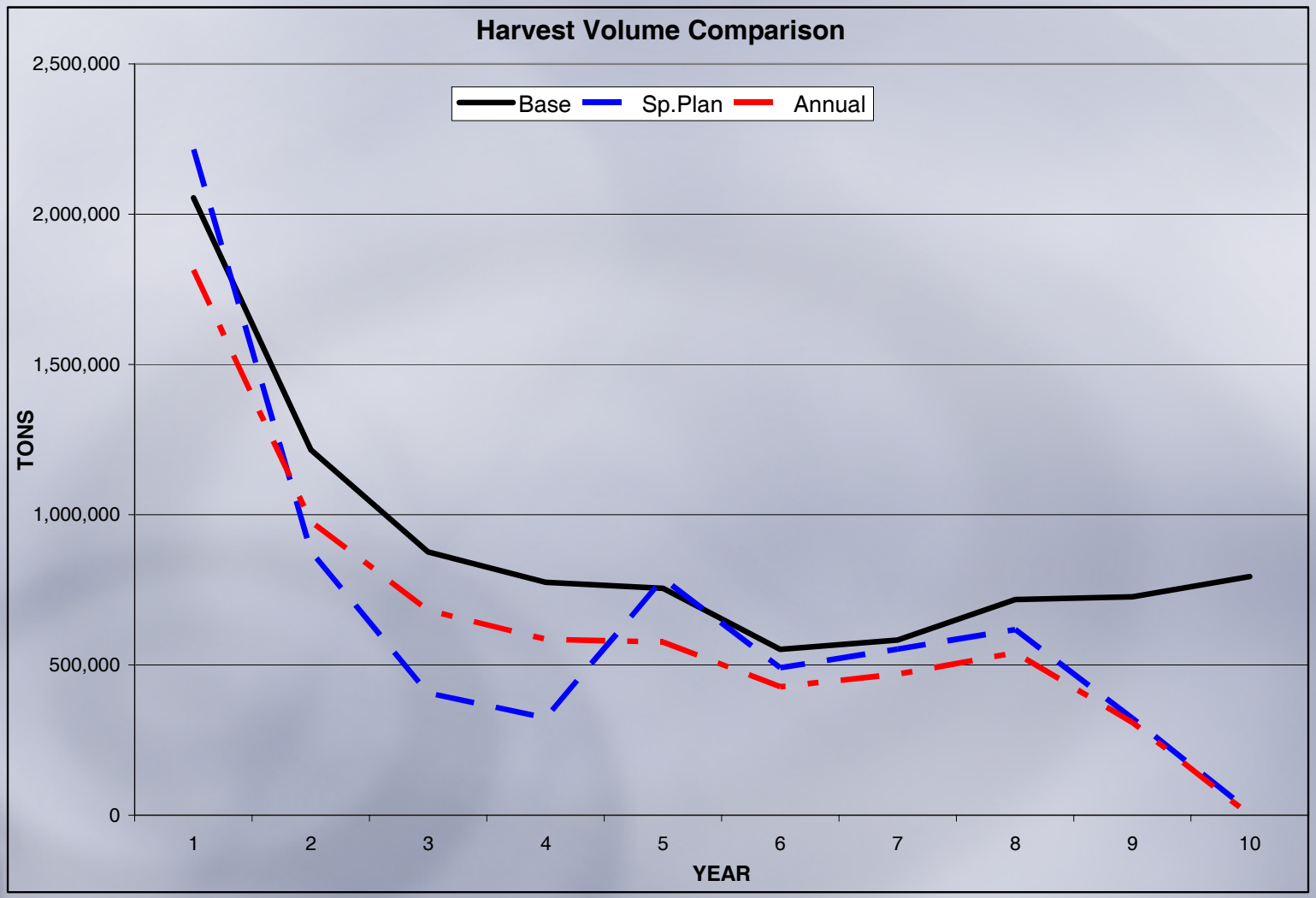
Model Comparison



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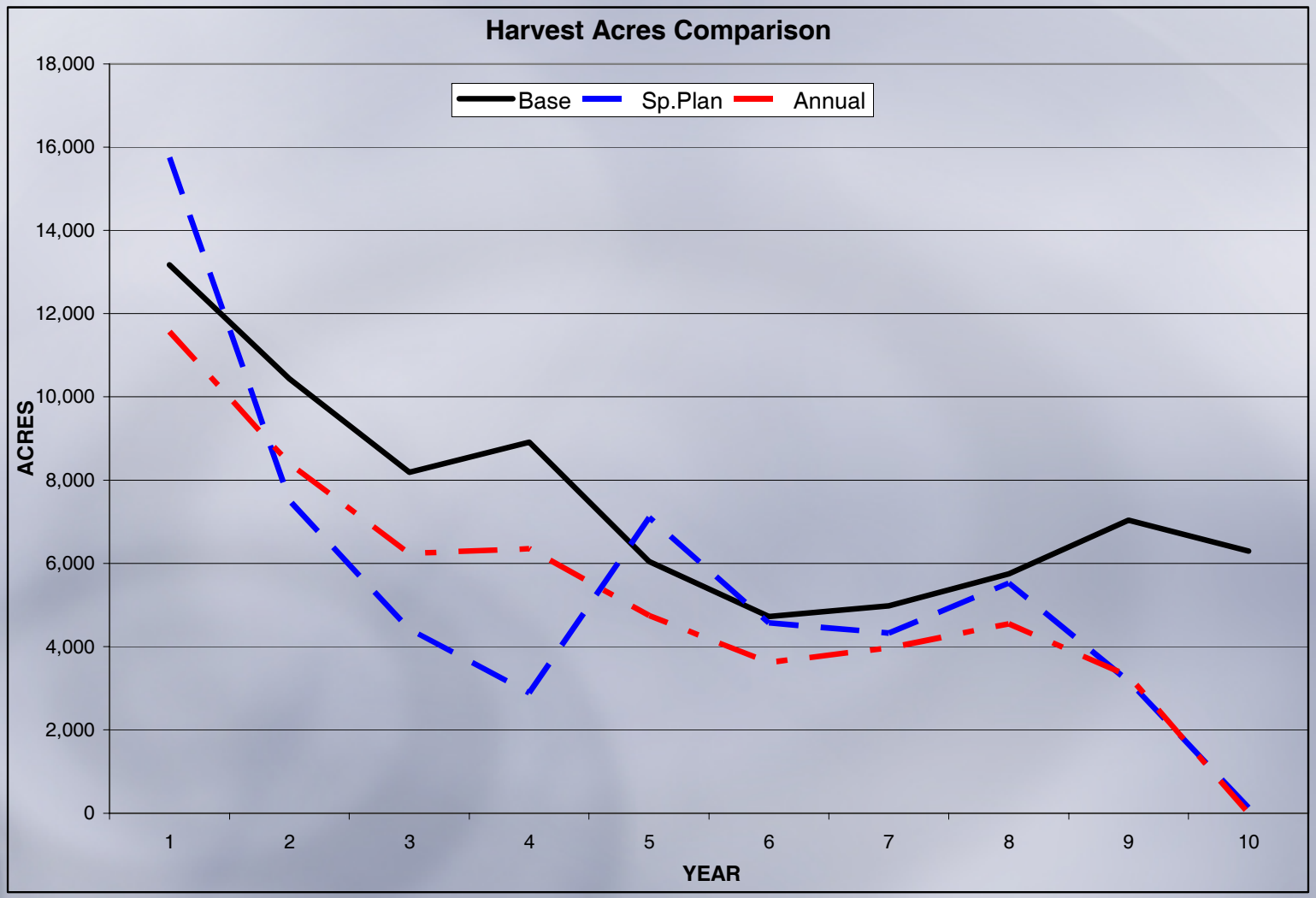
Model Comparison



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Results-Pine Harvest Volumes

Average Annual Pine Harvest Volumes Years 1..10

tons	Base	Sp.Plan	Annual
PST	462,873	300,888	299,261
PCNS	316,454	257,639	243,327
PPWD	125,687	101,986	95,560
TOTAL	905,014	660,513	638,148

- Spatial Harvest Planning over 10 Years
  - 27% Reduction in harvest volume
  - 35% Reduction in sawtimber harvest volume
  - The impact of spatial restrictions is significant

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Results-Pine Harvest Volumes

Average Annual Pine Harvest Volumes Years 1..10

tons	Base	Sp.Plan	Annual
PST	462,873	300,888	299,261
PCNS	316,454	257,639	243,327
PPWD	125,687	101,986	95,560
TOTAL	905,014	660,513	638,148

- Harvest Planning 1 Year at a Time
  - 29% Reduction in harvest volume
  - 35% Reduction in sawtimber harvest volume

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Results – Harvest Acres

Average Annual Harvest Acres Years 1..10

acres	Base	Sp.Plan	Annual
Clear cut	7,554	5,539	5,274

- Spatial Harvest Planning over 10 Years
  - 27% Reduction in final harvest acres

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Results – Harvest Acres

Average Annual Harvest Acres Years 1..10

acres	Base	Sp.Plan	Annual
Clear cut	7,554	5,539	5,274

- Harvest Planning 1 Year at a Time
  - 30% Reduction in final harvest acres

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Results – Net Revenue

Total, Per Acre, & Average Annual Per Acre Net Revenues Years 1..10

	Base	Sp.Plan	Annual
NetRev	$265	$192	$187
T NR/AC	$1,667	$1,210	$1,177
A NR/AC	$166.70	$120.97	$117.75

** Net Revenue in millions of dollars*

- Spatial Harvest Planning over 10 Years
  - Net Revenue is 27% lower
  - Impact of Spatial Requirements
    - Lower Harvest Volume
    - Less favorable product mix

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Results – Net Revenue

Total, Per Acre, & Average Annual Per Acre Net Revenues Years 1..10

	Base	Sp.Plan	Annual
NetRev	$265	$192	$187
T NR/AC	$1,667	$1,210	$1,177
A NR/AC	$166.70	$120.97	$117.75

** Net Revenue in millions of dollars*

- Harvest Planning 1 Year at a Time
  - Net Revenue is 29% lower
  - $5 Million loss in Net Revenue by not planning harvests in a spatial manner over time
    - Additional volume loss and shift in product mix

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Results – NPV

Total, Per Acre, & Average Annual Per Acre NPV Years 1..10

	Base	Sp.Plan	Annual
NPV	$195	$150	$147
T NPV/AC	$1,229	$944	$923
A NPV/AC	$122.93	$94.41	$92.33

** NPV in millions of dollars*

- Spatial Harvest Planning over 10 Years
  - A 23% loss in NPV over 10 years
  - Impact of Spatial Requirements

NPV is the primary criterion for evaluation of alternatives because the goal is to manage the forest asset in an economically efficient & financially responsible manner.

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Results – NPV

Total, Per Acre, & Average Annual Per Acre NPV Years 1..10

	Base	Sp.Plan	Annual
NPV	$195	$150	$147
T NPV/AC	$1,229	$944	$923
A NPV/AC	$122.93	$94.41	$92.33

** NPV in millions of dollars*

- Harvest Planning 1 Year at a Time
  - A 25% loss in NPV over 10 years
  - $3 Million loss in NPV by not planning harvests in a spatial manner over time

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Results

- Spatial Restrictions have a large impact on optimal harvest allocation
  - 23% reduction in NPV over 10 years
- Additional impact by not planning harvests in a spatial manner over time
  - Additional 2% reduction in NPV over 10 years
  - This used sophisticated allocation tools as well
- Manual Allocation would have significantly lower results

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Discussion

- We do not expect forest managers to follow the optimal plan exactly
  - Data is not perfect
  - Conditions change
    - Weather, markets, etc.
- Manually allocating harvests annually may have unintended consequences
  - Snowball effect
    - Impacts harvest flows, harvest acres, and silviculture
    - Not following the plan affects everything – especially ECONOMICS
- Forest Management Plans should not be considered a cafeteria plan (a la carte)
  - The parts go together as a set
    - Cutting at a level that assumes a given investment in silviculture and not making the investment violates the basic assumptions of the model

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Conclusions

- Forest management planning tools are much more sophisticated than in the past
  - GIS and inventory data are much more detailed
  - High intensity silvicultural alternatives available
  - Growth & yield models simulate their responses
  - Ability to implement planned activities across the forest in the presence of spatial regulations
- Using these sophisticated tools can lead to increased returns to timberland investors
  - Cannot violate underlying assumptions of model
  - Arbitrary deviations from plan in implementation risks significant loss in NPV or harvest volume

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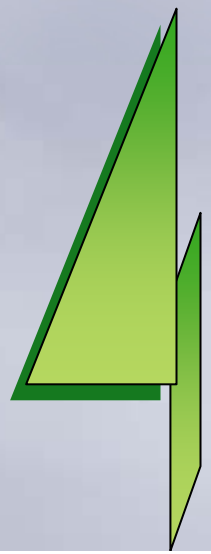

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