PRELIMINARY RESULTS

An Optimistic Outlook on Spruce Budworm Impacts and Mitigation Opportunities in Maine

Preliminary Results

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Background on CFRU Project Objectives

1) Customize the Spruce Budworm Decision Support System (DSS) for Maine:

   - Build SBW defoliation scenarios representative of levels observed in Maine from available historical data;

   - Project tree-lists from Maine FIA plots with the FVS-NE in combination with NB tree-level defoliation-damage relationships to quantify stand volume impacts for Maine stands;

2) Produce from the Maine-calibrated DSS, maps of stand volume impact by outbreak scenario from participating CFRU member GIS data and FIA-based stand yield projections;

3) Develop a non-spatial timber supply model for Maine using FIA data, FVS projections, typical silviculture systems, and SBW outbreak and defoliation-impact relationships to help design and quantify the benefits of alternative mitigation portfolios for a wide range of possible outbreak start dates (2015, 2025, 2035, 2045) and severities.

Objectives Today

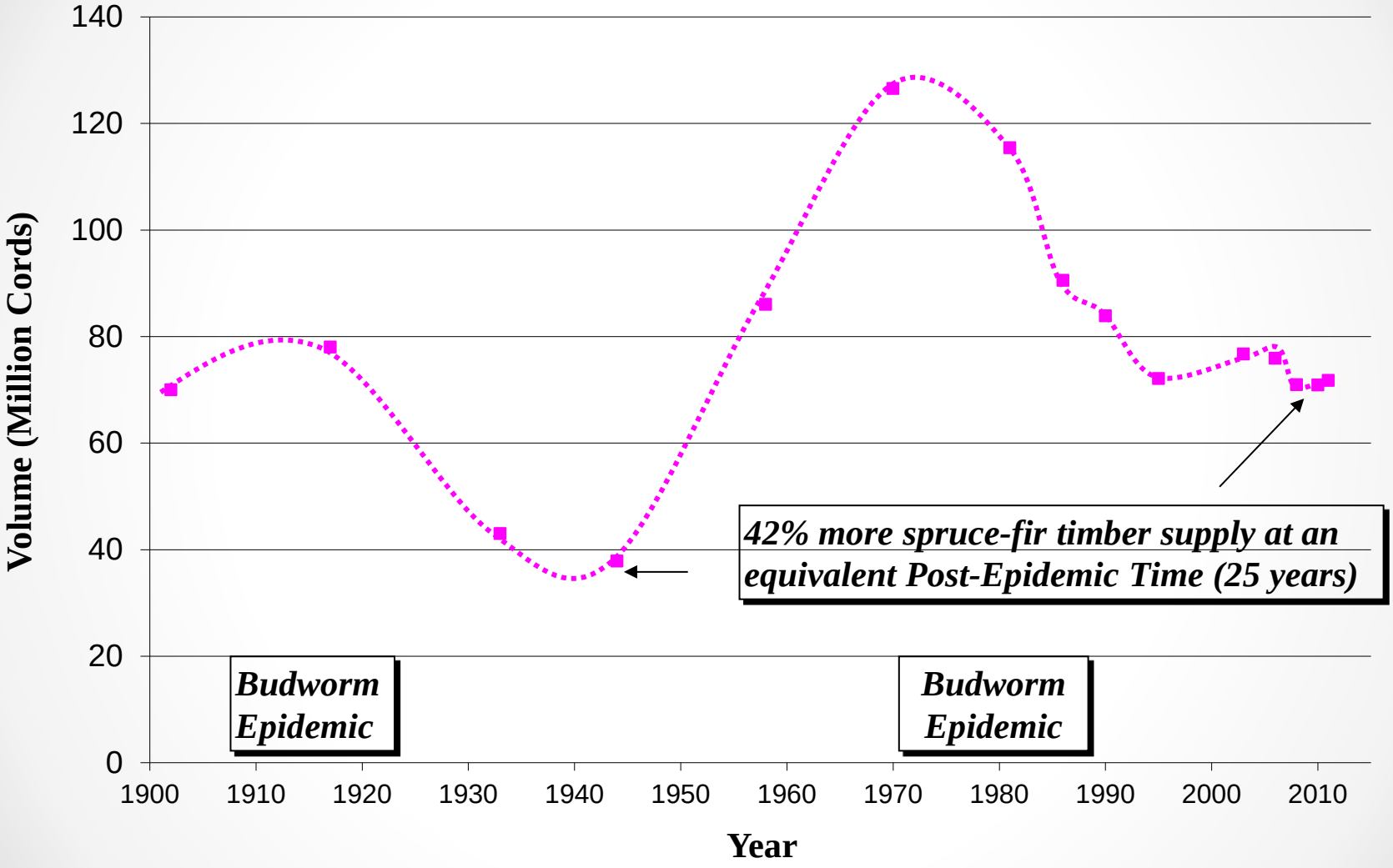
1) Provide some background on re-construction of the 1970-80s spruce budworm (SBW) outbreak for Maine.

2) Briefly discuss stand-level modeling in FVS-NE used to project the impacts of this historic outbreak on Maine's current forest inventory, as characterized by the Forest Inventory and Analysis program.

3) Discuss the design and background assumptions of the state-wide wood supply model built for this SBW impact analysis.

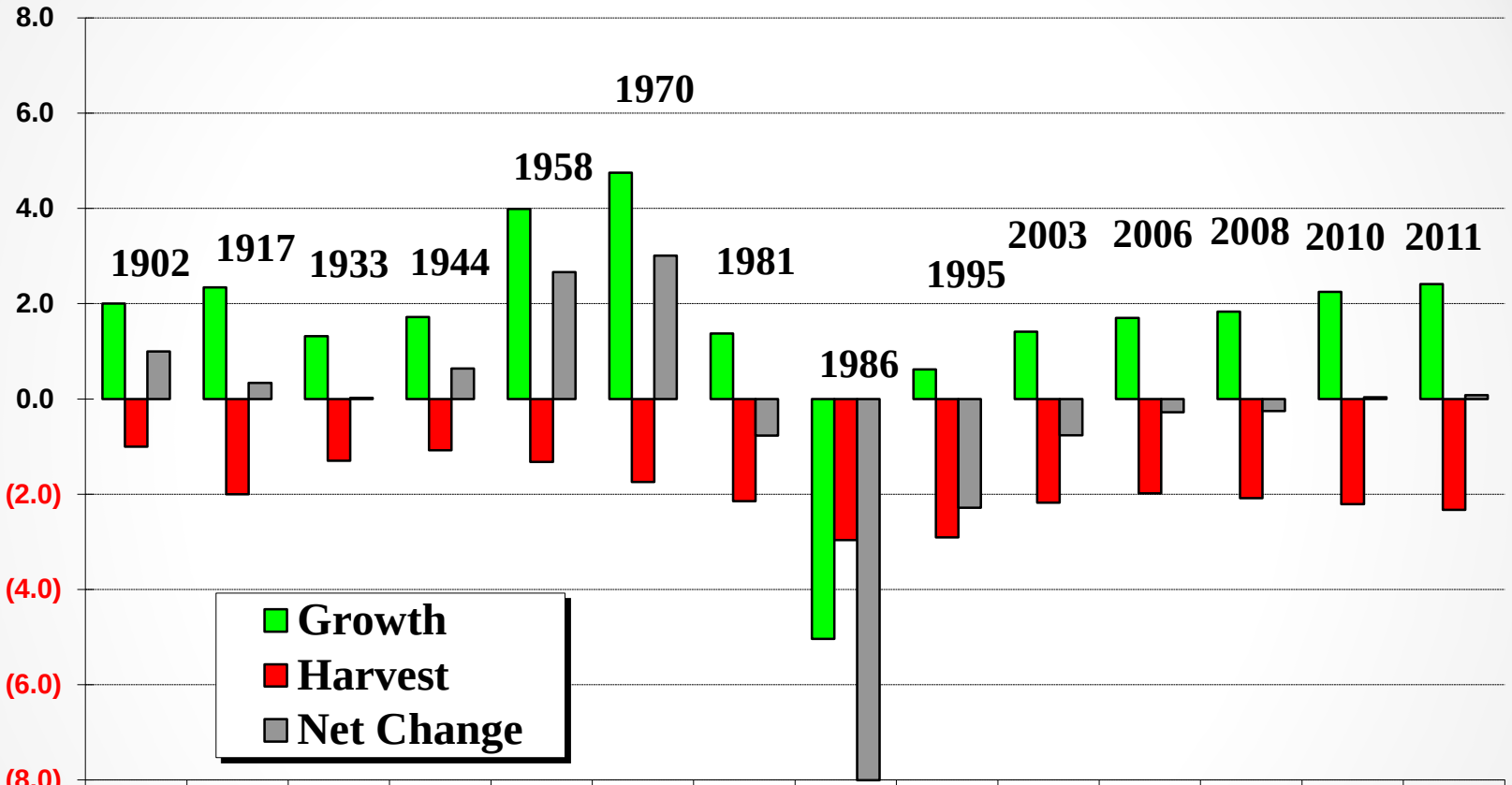
4) Present preliminary SBW harvest impact results for Maine, and quantify potential benefits of existing mitigation options (e.g., harvest re-planning, salvage, foliage protection).

Maine's Spruce-Fir Growing Stock Trends



Curtsey of Ken Laustsen, Maine Forest Service

Maine's Spruce-Fir Timber Supply: Annualized Net Growth, Harvest, and Net Change (Million Cords per Year)

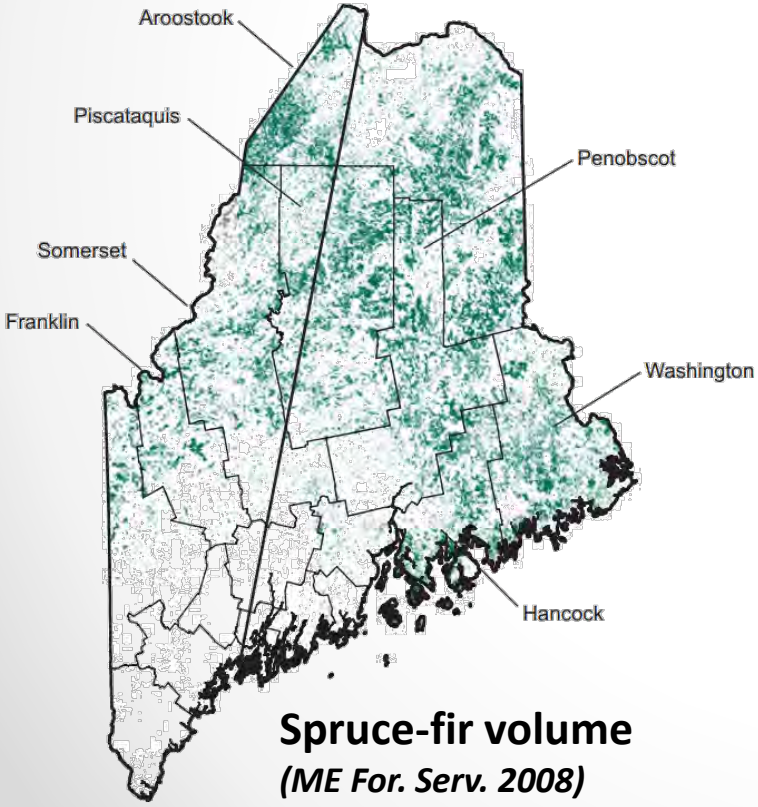


	1902	1917	1933	1944	1958	1970	1981	1986	1995	2003	2006	2008	2010	2011
Growth	2.0	2.3	1.3	1.7	4.0	4.8	1.4	(5.0)	0.6	1.4	1.7	1.8	2.2	2.4
Harvest	(1.0)	(2.0)	(1.3)	(1.1)	(1.3)	(1.7)	(2.1)	(3.0)	(2.9)	(2.2)	(2.0)	(2.1)	(2.2)	(2.3)
Net Change	1.0	0.3	0.0	0.6	2.7	3.0	(0.8)	(8.0)	(2.3)	(0.8)	(0.3)	(0.3)	0.0	0.1

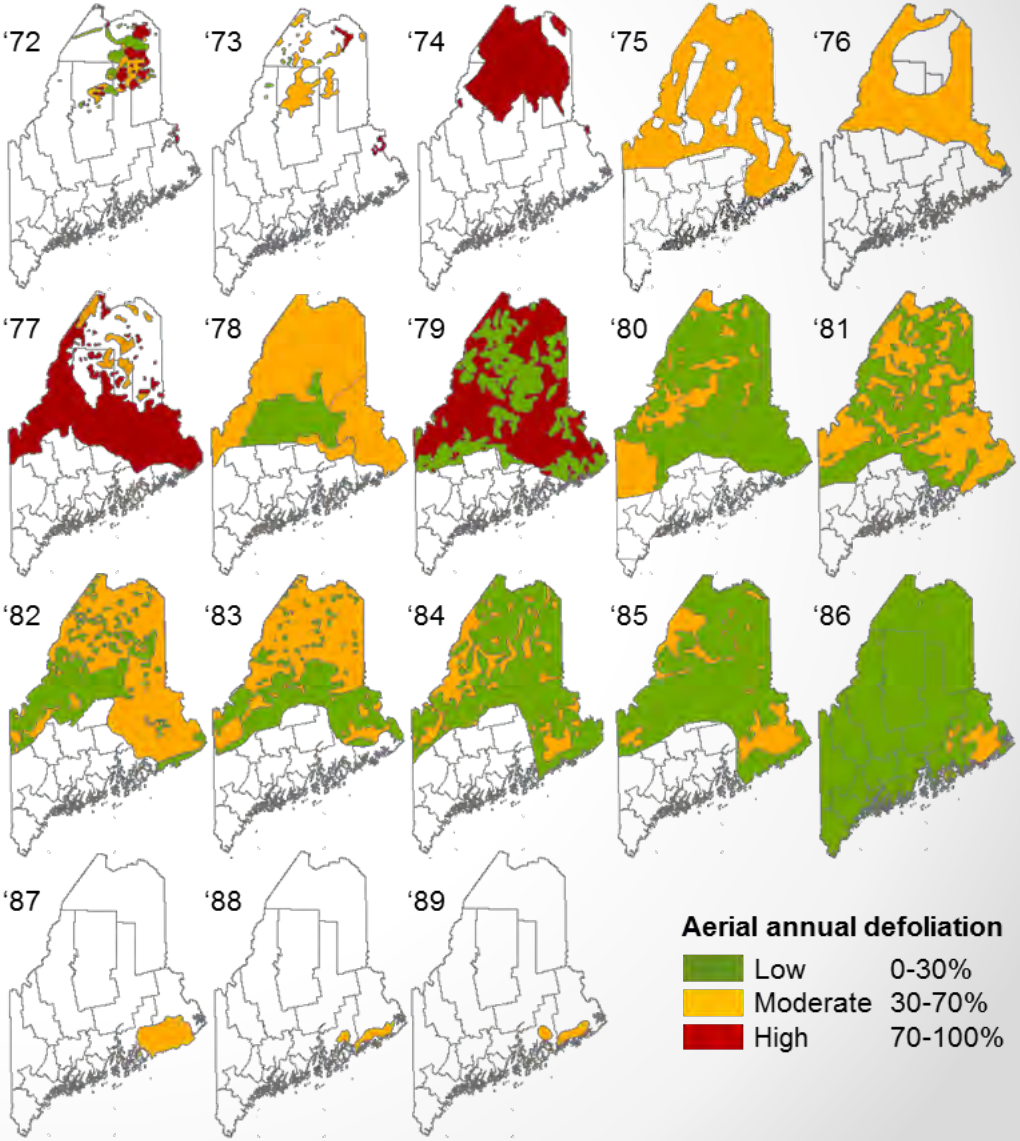
Curtsey of Ken Laustsen, Maine Forest Service

Characterizing 1970-80s SBW Defoliation in Maine

- Aerial sketch maps of defoliation digitized from Maine Forest Service reports: 1972-1989
  - Taisa Brown, BScF Thesis – UNB
  - Supervised by Dr. David MacLean



Spruce-fir volume
(ME For. Serv. 2008)

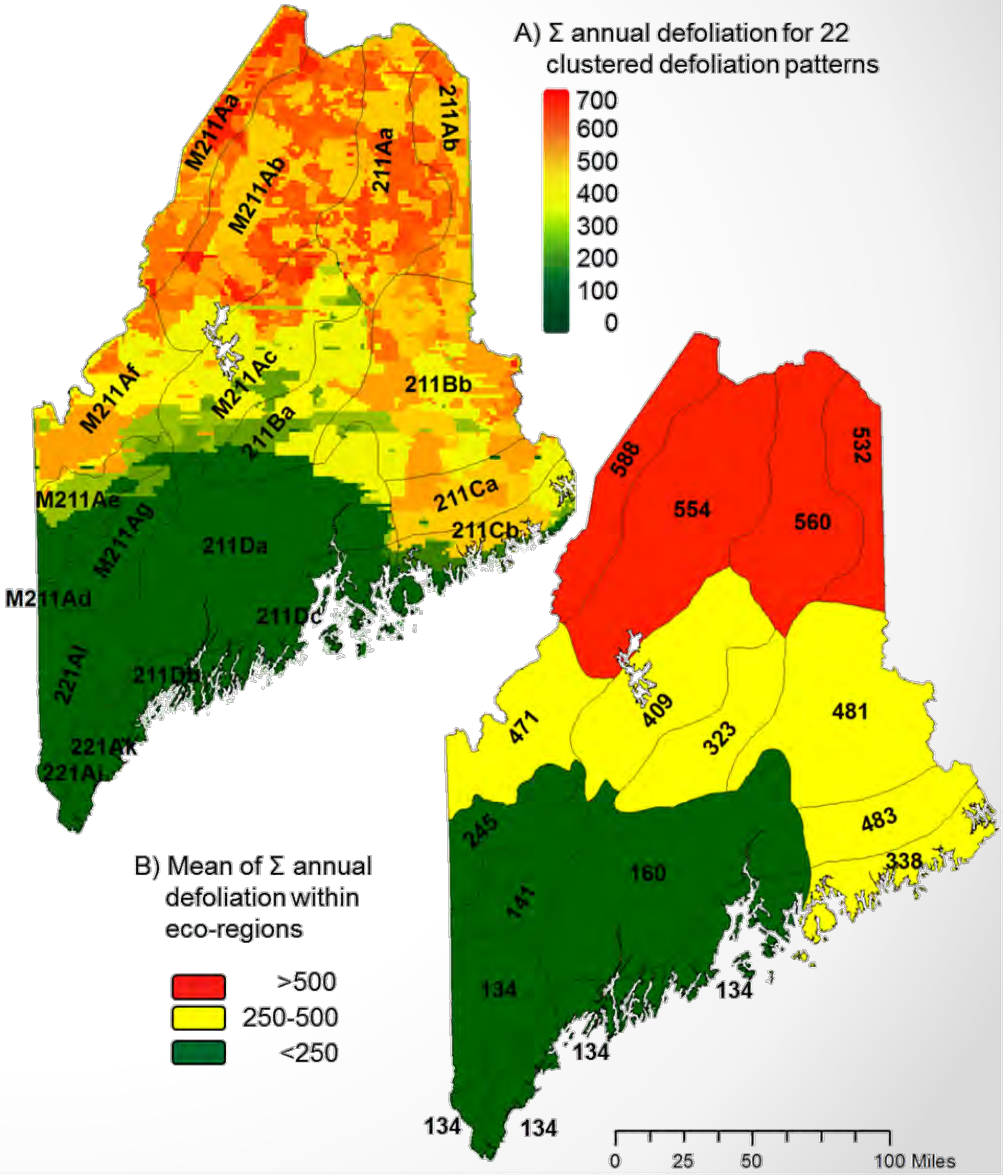


Characterizing 1970-80s SBW Defoliation in Maine

- Identified **22 generalized temporal defoliation patterns** using k-means clustering on 1972-1989 maps using 2X2 km grid cells (A).
  - Methods similar to D. Gray *et al.* (2000) in Quebec.

- **Defoliation severity increased from southwest to northeast** and visually corresponded well with eco-region boundaries (B).

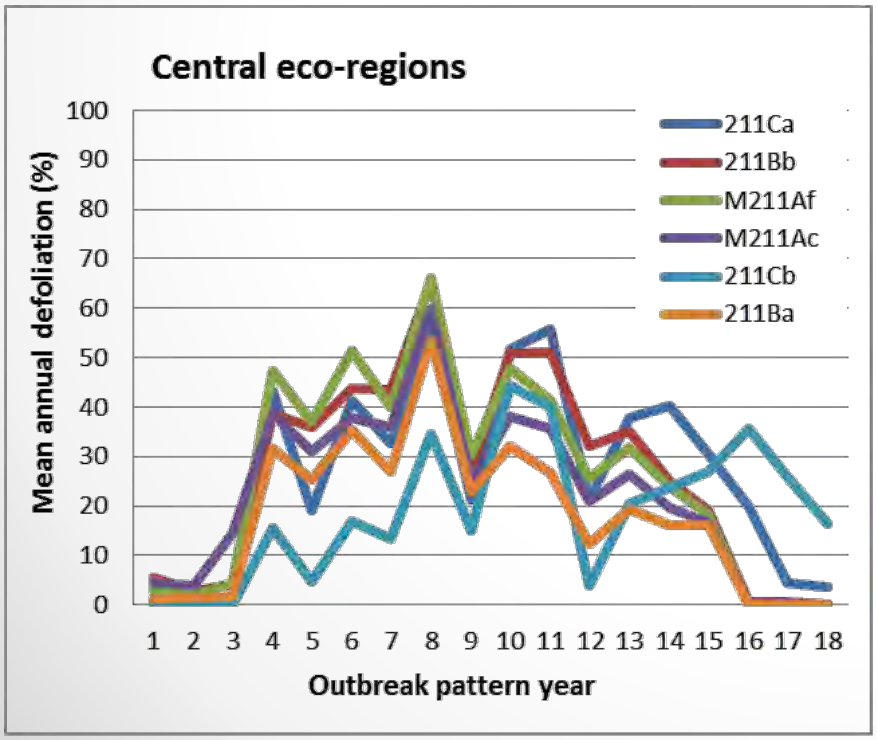
- Eco-regions having < 250% Σ defoliation (green) were considered **not at risk of future outbreak**.

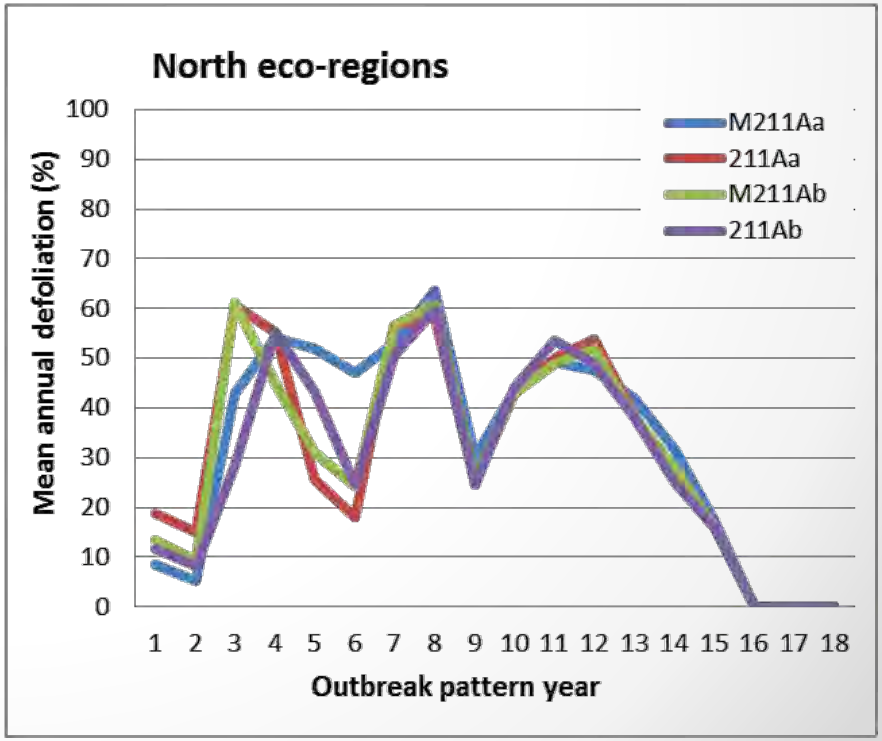


1970-80s SBW Defoliation Patterns: **Confounding Issues**

- At no time did mean annual defoliation exceed 65% across eco-regions, or exceed 75% among clustered patterns.

- If these defoliation patterns were used in the SBWDSS, negligible tree mortality would be projected.





1970-80s SBW Defoliation Patterns: **Confounding Issues**

- While these patterns may indeed reflect mean regional defoliation observed, there are a number of confounding issues that preclude use of this information in constructing an 'unprotected' Maine outbreak pattern for use in the SBWDSS.

  - Foliage protection treatments undoubtedly reduced defoliation.

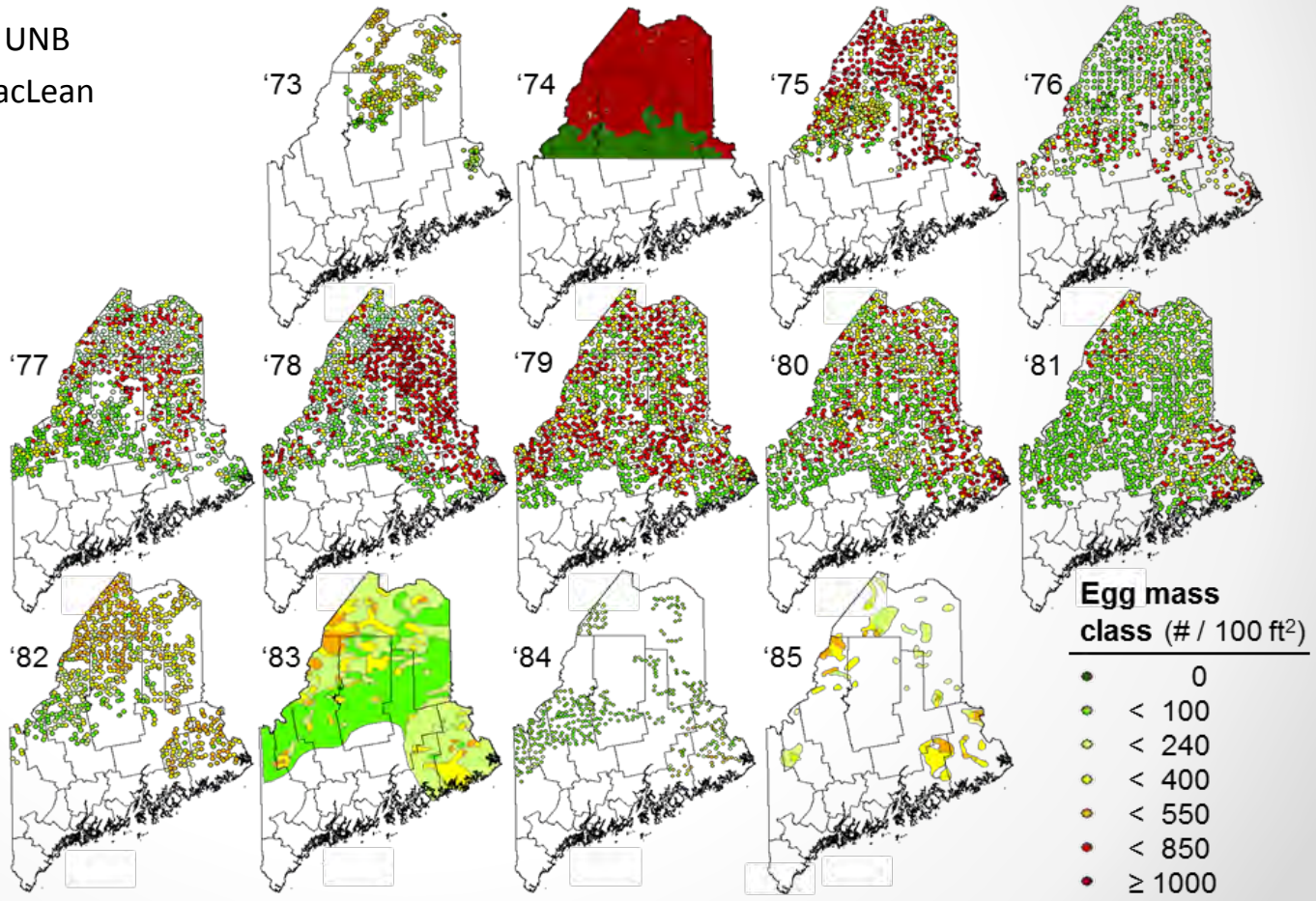
  - Unclear exactly which host species the mapped defoliation pattern is reflective of, or whether the composition of non-host or less preferred host (red & black spruce) influenced the observed aerial defoliation estimates.

  - The degree of averaging in the observed records (low resolution defoliation classes and sketch mapping), and further simplification in our analysis (2 X 2 km grid cells, mean regional patterns), compromised our ability to reproduce a representative distribution of defoliation patterns in terms of both severity and frequency.

Characterizing 1970-80s SBW Population Trends in Maine

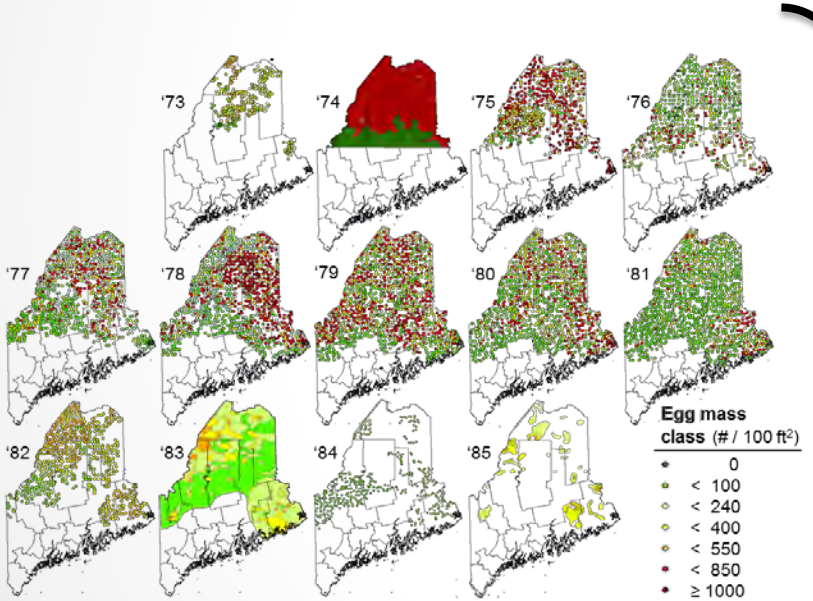
Ground-based egg-mass density samples digitized from Maine Forest Service reports: 1973-1985

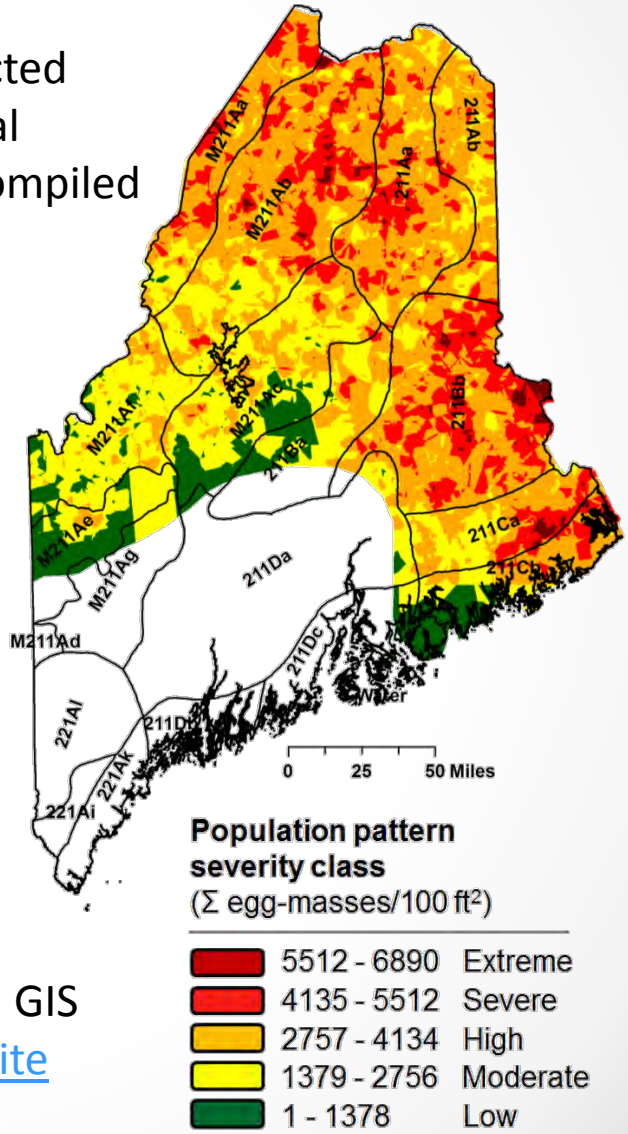
- Taisa Brown, BScF Thesis – UNB
- Supervised by Dr. David MacLean



Characterizing 1970-80s SBW Population Trends in Maine

- Converted points to polygons (Voronoi), intersected each survey-year layer, and dissolved on identical temporal egg-mass density patterns to yield a compiled spatiotemporal coverage of all survey years.

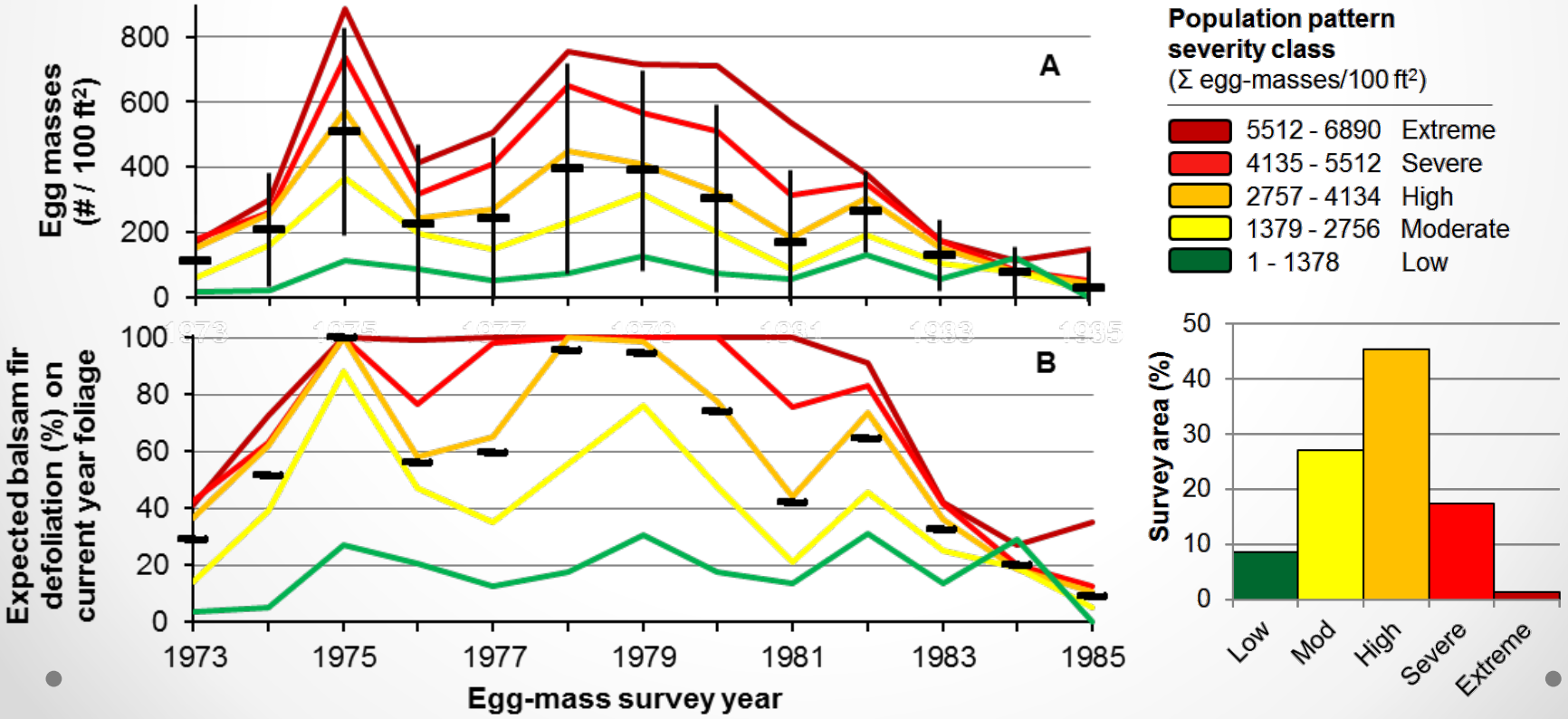




- Geo-databases for all population and defoliation GIS layers **available now** on the internal CFRU website

Characterizing 1970-80s SBW Population Trends in Maine

- Identified **5 generalized temporal population patterns** by partitioning patterns into equal-interval groups based cumulative egg-masses from 1973-1985 (A).
- 100% fir defoliation @ 400 egg-masses / 100 ft^2 foliage (B; Simmons 1974).
- Provides range of temporal severity, but also spatial distribution of severity!



Custom SBW Impact Forecasts in FVS-NE for Maine

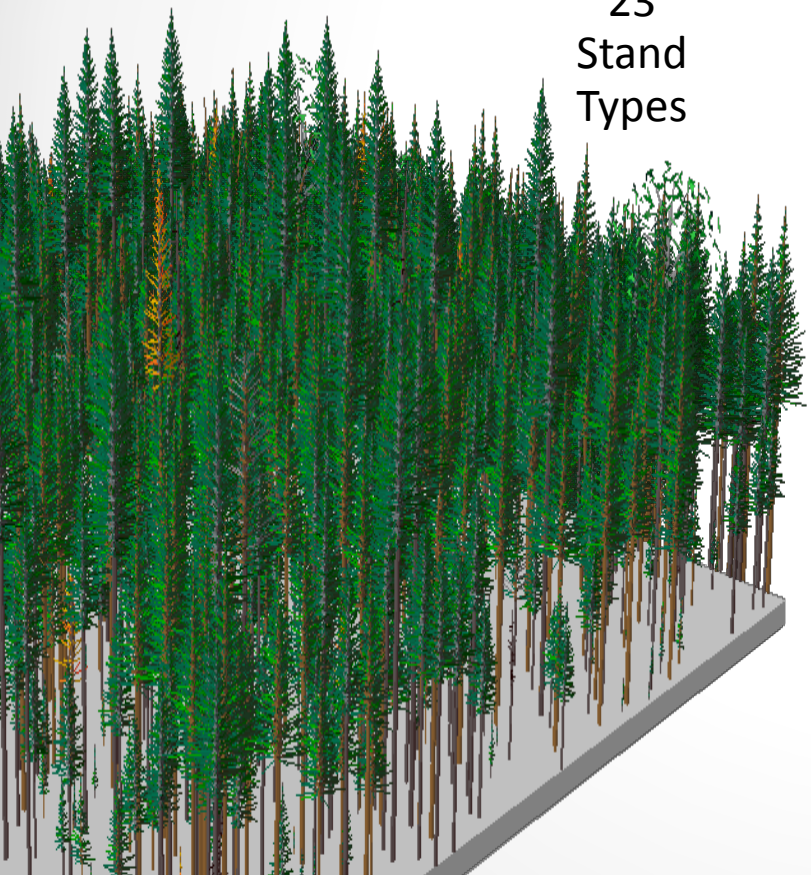
Full Range of Population Levels

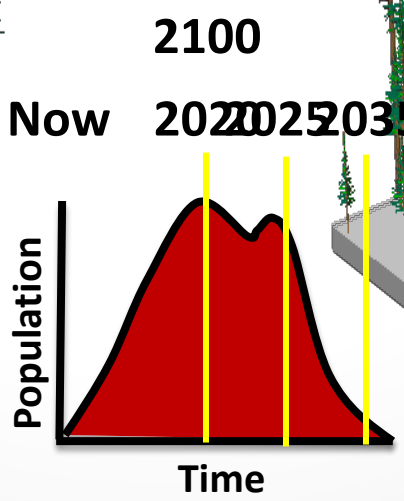
Separated Impacts by Host Species

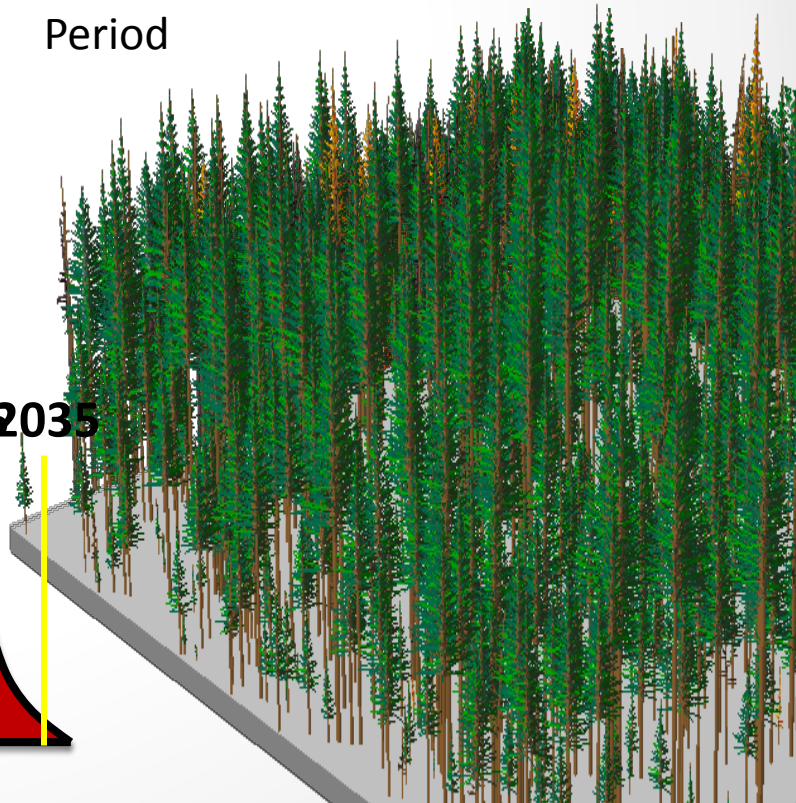
Stand Impact Matrix
1000s of Volume Impact Multipliers

23 Stand Types

Future Time Period







Maine Wood Supply / SBW Impact Model

- Model design objective:
  - Develop a non-spatial wood supply model for Maine timberlands (17.19 million acres) that captures sufficient forest inventory detail (species, productivity, regions) and contemporary management practices (harvest levels, treatments, treatment levels) to provide reasonable projections of forest growing stock and harvest with and without spruce budworm.

- To address the following questions:

  1) How much harvest impact can be expected?

  2) What can be done to mitigate impact in advance of an outbreak?

  3) What can be done to mitigate impacts during an outbreak?

Maine Wood Supply / SBW Impact Model

- Inventory based on FIA 2006-2010 plots (stockable timberland)
- Growth and yield based on FVS-NE projections
  - Included the Acadian ingrowth model.
  - Included limits on tree-size by species and maximum basal area by stand type.
  - Used New Brunswick merchantability specifications (Erdle and Ward 2008).

- Landscape classification
  - 135 stand types (species, timber size, stocking).
  - Two site types: High (sites 3-5), Low (site 6); excluded non-productive (7).
  - Two SBW outbreak zones: 'At Risk' (71%) and 'Not At Risk' (South).
  - Excluded area (4.6%) with slope > 30% and elevation > 2500 ft.
  - Unable to identify riparian or other spatially explicit no harvest or restricted harvest zones.

Maine Wood Supply / SBW Impact Model

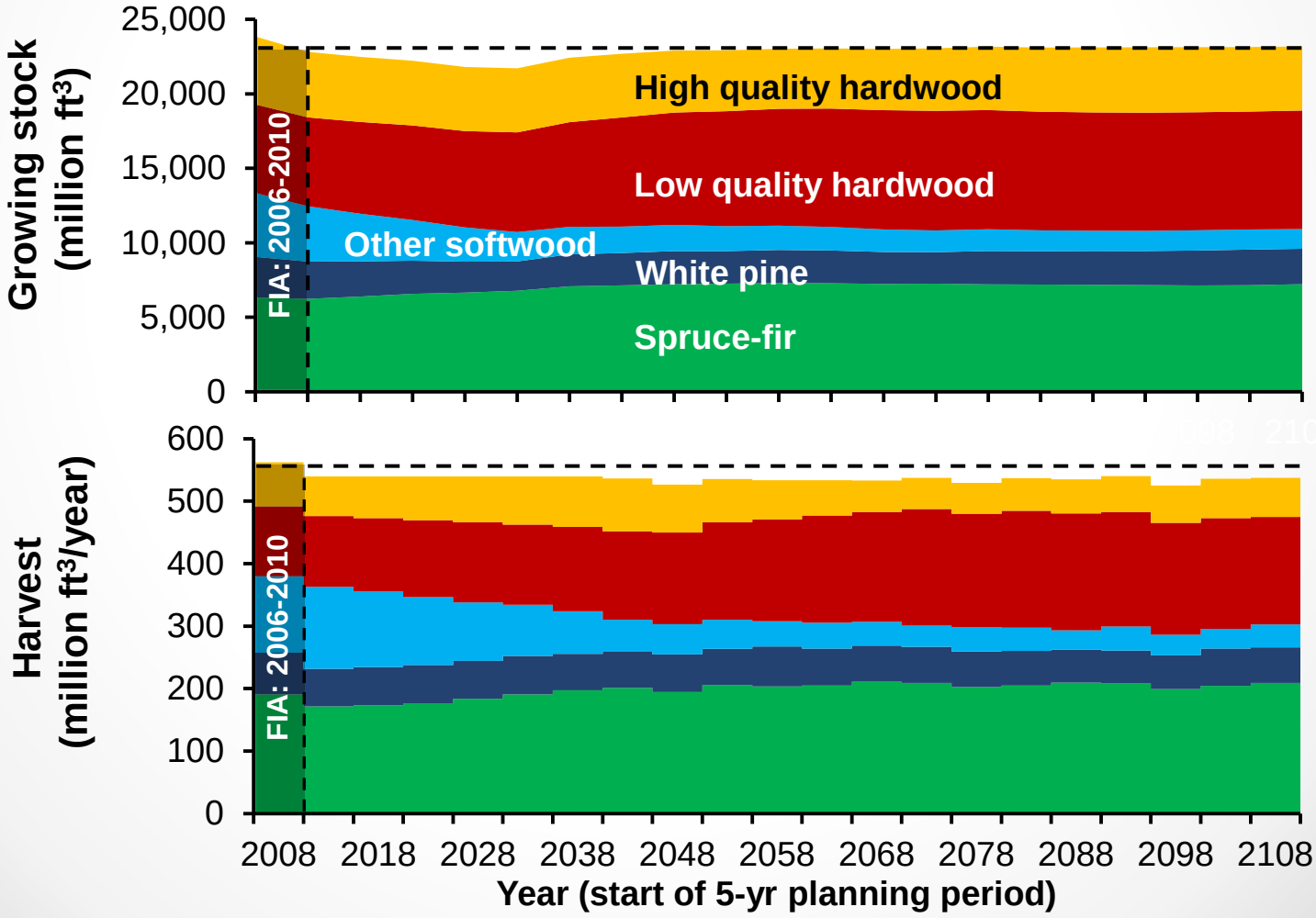
- Baseline scenario
  - Established to reflect recent (1990-2010) forest management practices in Maine forward 100 years.
    - **Total harvest & log harvest,** and variation by species-product group
    - Area and variation of clearcut, partial cut, and shelterwood treatments
  - Constrained 1st planning period (2008-2012; inventory update) to meet average harvest volumes and treatment amounts reported for 2006-2010 in:
    - Maine Forest Service Wood Processing and Silviculture Reports
    - FIA estimated total and sawlog growing stock removals

Maine Wood Supply / SBW Impact Model

- Baseline scenario
  - Maximized total harvest discounted at 5%
    - Comparable to model objectives used in other wood supply analysis in Maine (Wagner et al. 2003; Sewall 2010).
    - Weighted spruce-fir harvest value twice as much as other species.
  - Flow Constraints (2013-2112):
    - Non-declining total harvest and spruce-fir harvest.
    - Ending merchantable volume by species-group ≥ 2013 levels.
    - Log harvest by species-group ≥ 2013 levels.
    - Clearcut area ≤ mean area clearcut from 2006-2010 (about 4% of total treated area).
    - Partial-cut and Shelterwood area ≥ mean area treated from 2006-2010.

Maine Wood Supply / SBW Impact Model

- Baseline profile

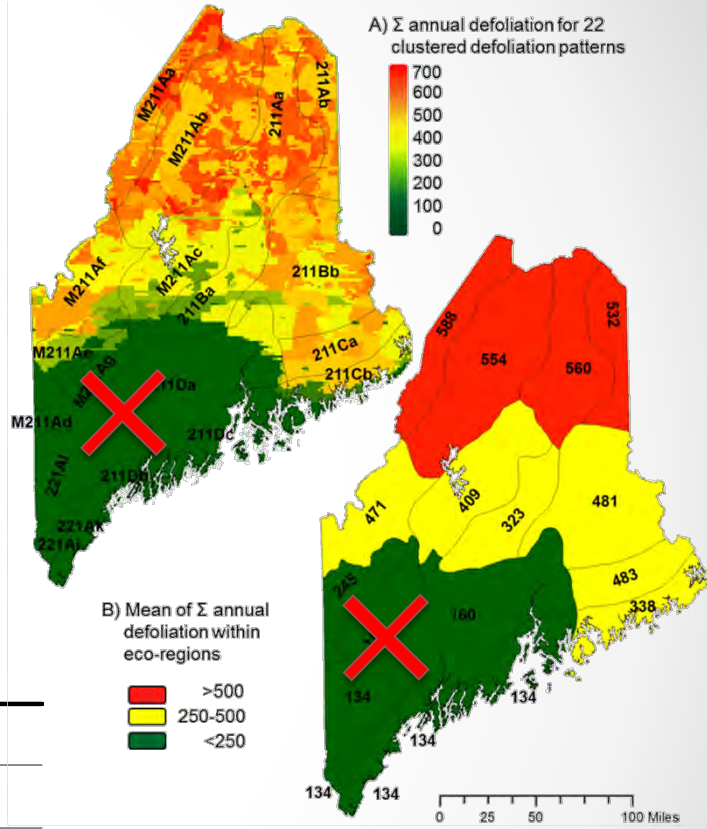


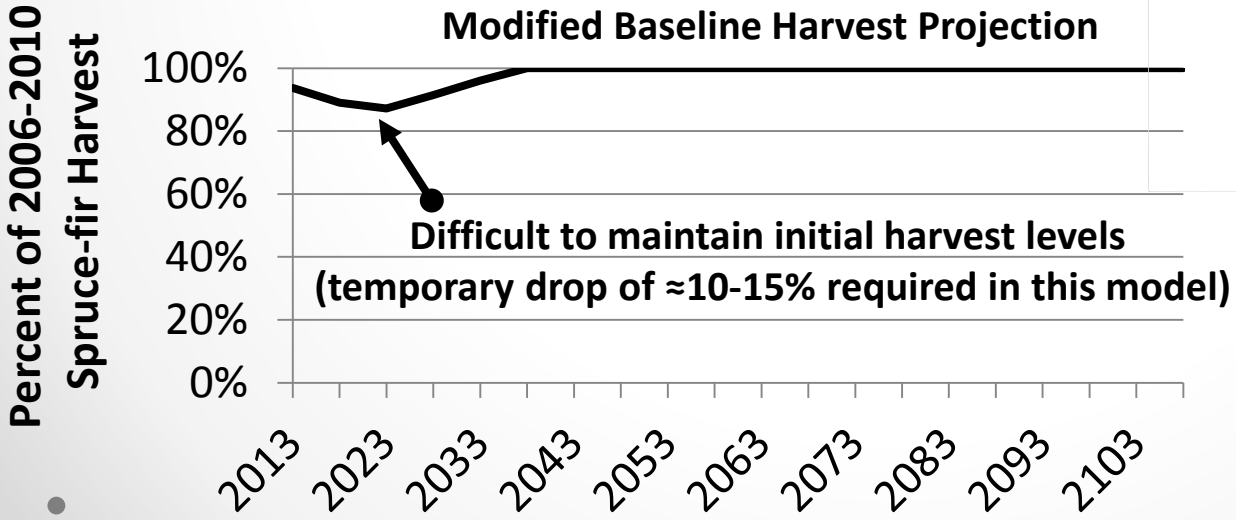
Maine Wood Supply / SBW Impact Model

- Baseline validation
  - Excellent inventory alignment with FIA (assuming same merchantability standards).
    - For the final model we used New Brunswick's Task Force merchantability standards (Erdle and Ward 2008). As a result:
      - Spruce-fir growing stock was estimated to be 13% higher in model
      - Spruce-fir stud and timber logs 76% higher in model.
  - Significant long-term stand projection bias seemed apparent for many stand types based on FVS projected growth vs. FIA observations.
    - Overall, 43% lower merchantable volume increment in model
    - Though, spruce-fir increment was only 2% lower in model
  - This state-wide impact model should provide broad forest-level estimates of volume impacts for a given SBW population scenario.

Modified Baseline Scenario for Impact Analysis

- For impact modeling, only ‘at risk’ areas (north and central eco-regions) were considered (71% of total timberland).
- Non-declining harvest constraints were replaced with harvest flow fluctuation (≤5%) constraints to allow necessary harvest declines caused by SBW impact.



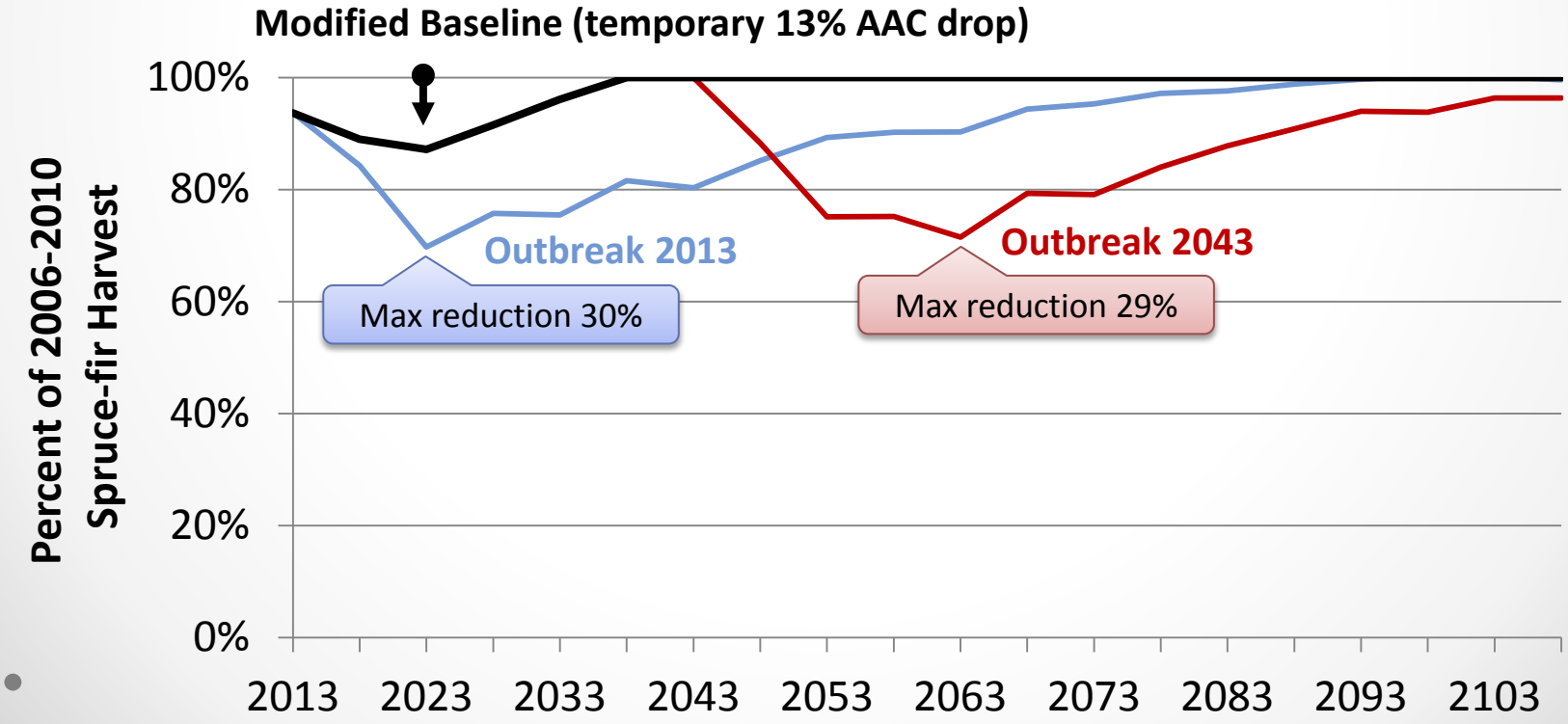


An Optimistic Outlook – and a Cautionary Note

- For any given SBW scenario, harvest reductions generated from this impact model are probably under-estimated for a number of reasons:
  - All stands assumed to be accessible.
  - This model uses a mathematical optimizer.
  - No spatial constraints were imposed.
  - No habitat, reserves, or watercourse buffer zone harvest restrictions were included.

Maine Wood Supply Impacts – Historic Outbreak Replay

- Average spruce-fir harvest reduction as a function of simple inventory loss calculations over a 30-yr outbreak window was estimated to be ≈20% for all 'at-risk' area in Maine.
  - This estimate was relatively insensitive to outbreak timing.

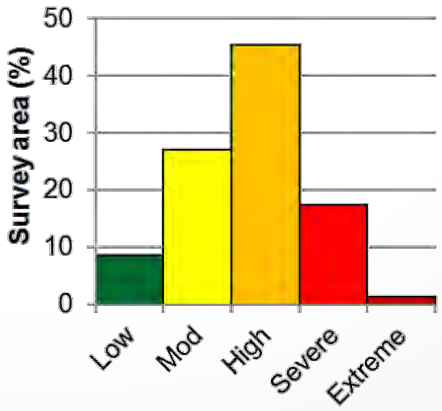


Mitigation Options Explored

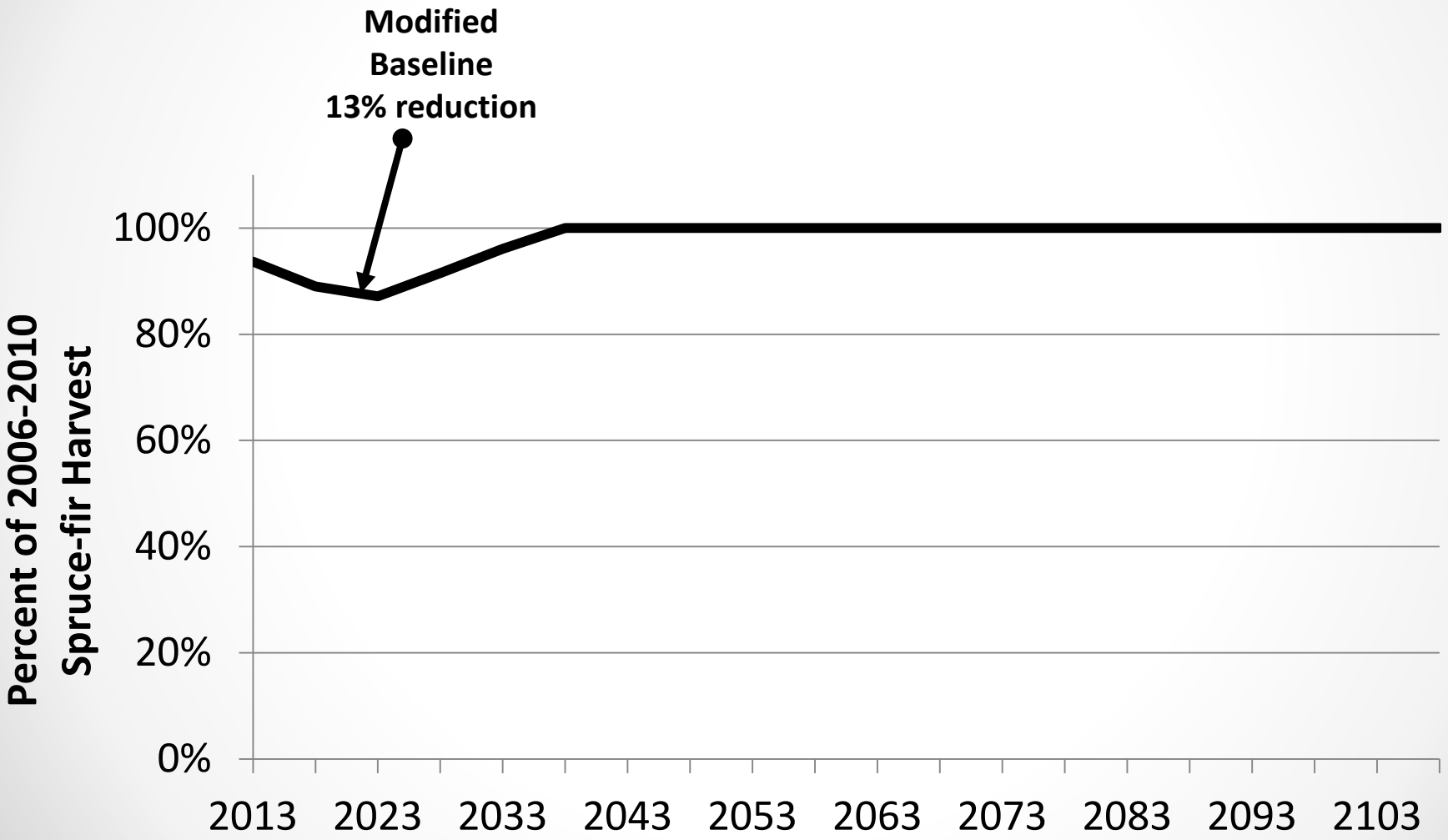
- Re-plan harvest to target severely defoliated stands first.

- Salvage (clearcut):
  - Operability: Spruce-fir volume ≥50 m^3/ha (750 ft^3/ac)
  - Live and dying or recently dead volume is captured.

- Foliage protection (10%, 20%, 40%, 70%, and 100% of area):
  - Double applications of BTK/yr when annual defoliation is projected to be ≥40%:
    - Extreme outbreak pattern: 10 years of protection required
    - Severe: 9 years
    - High: 8 years
    - Moderate: 6 years
    - Light: 3 years



Maine Wood Supply Impacts – Historic Outbreak Replay



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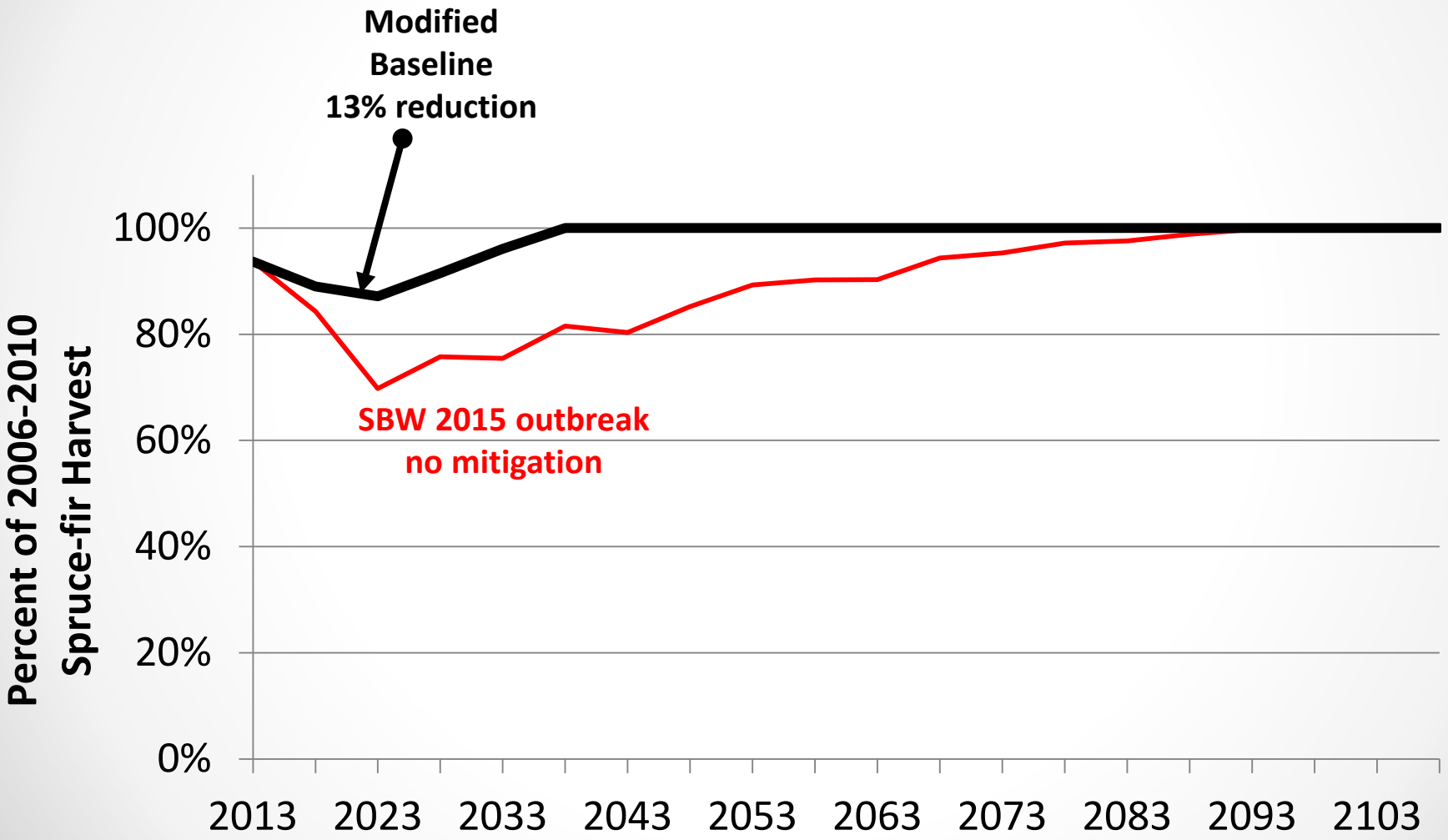

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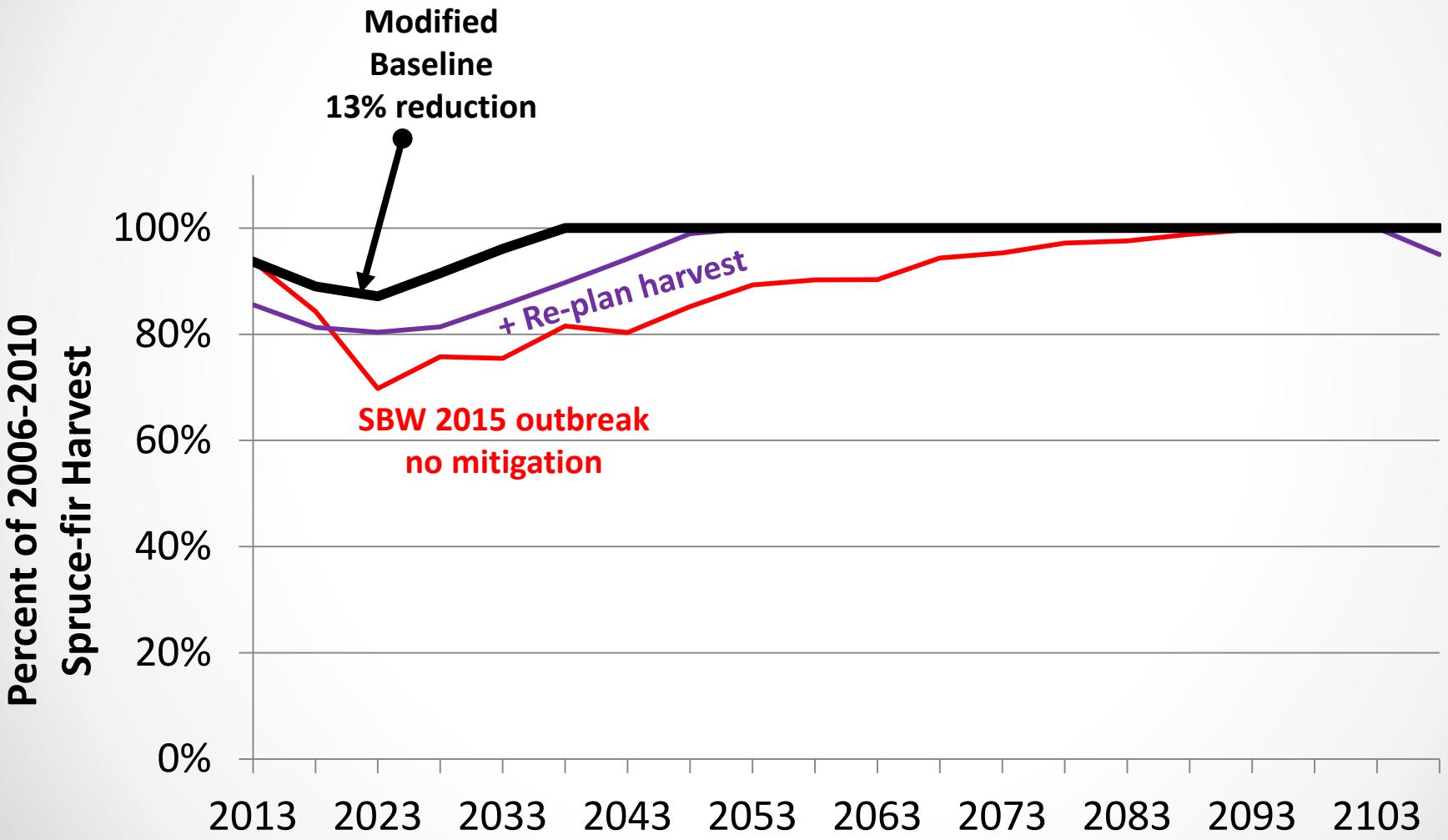

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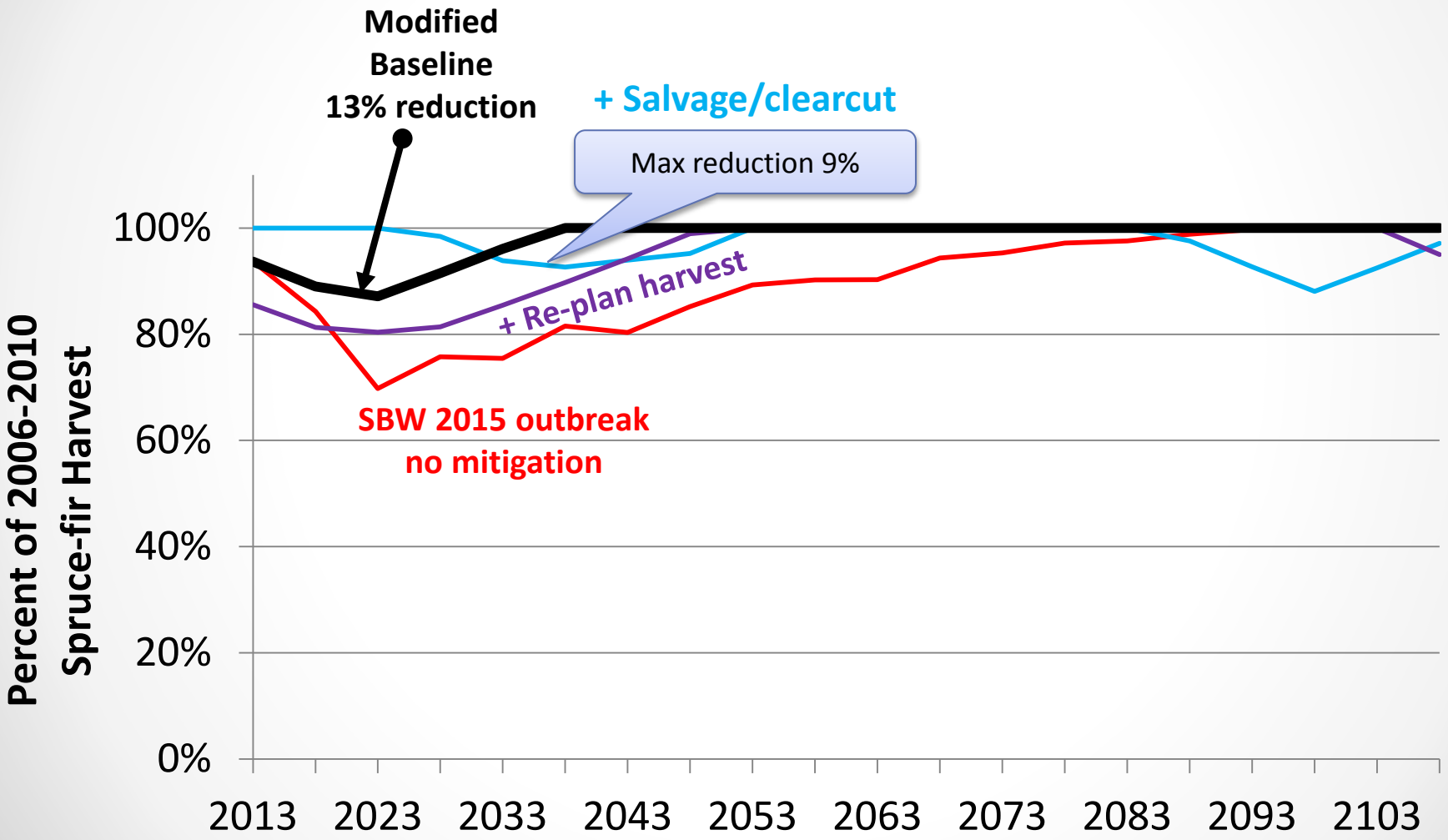

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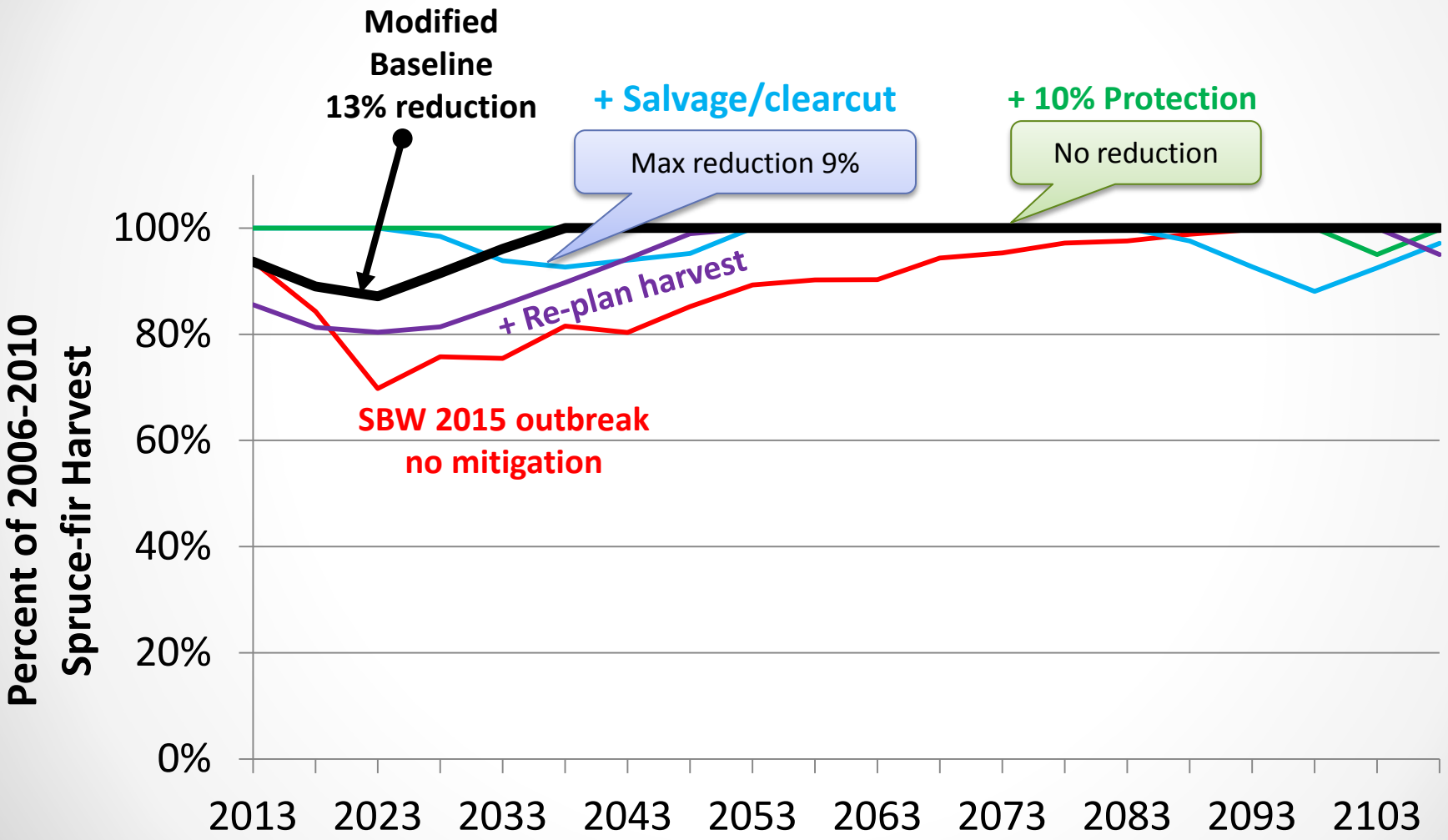
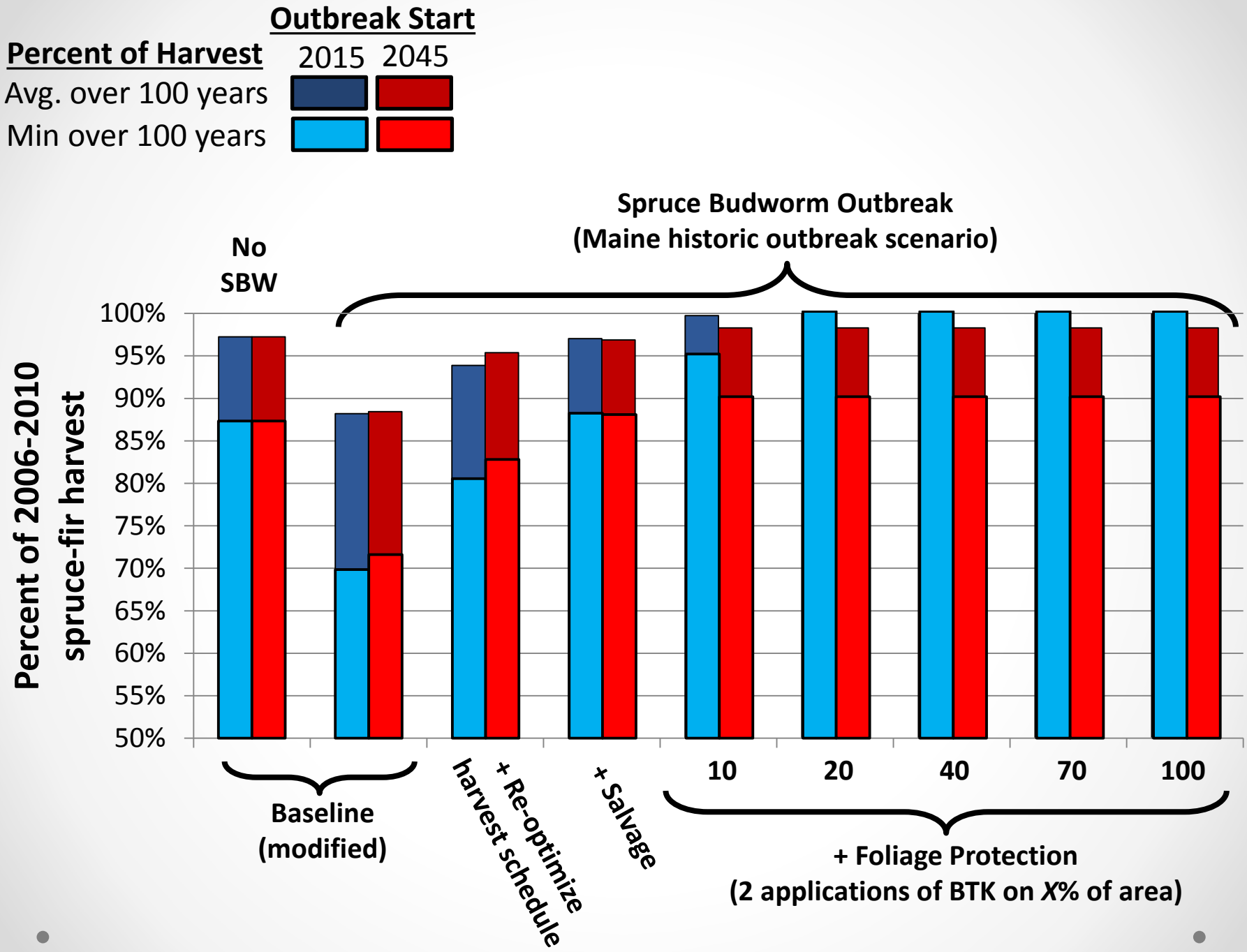



Outbreak Start
Percent of Harvest
2015 2045
Avg. over 100 years
Min over 100 years
Spruce Budworm Outbreak
(Maine historic outbreak scenario)
No SBW
Percent of 2006-2010 spruce-fir harvest
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
10
20
40
70
100
Baseline (modified)
+ Re-optimize harvest schedule
+ Salvage
+ Foliage Protection
(2 applications of BTK on X% of area)

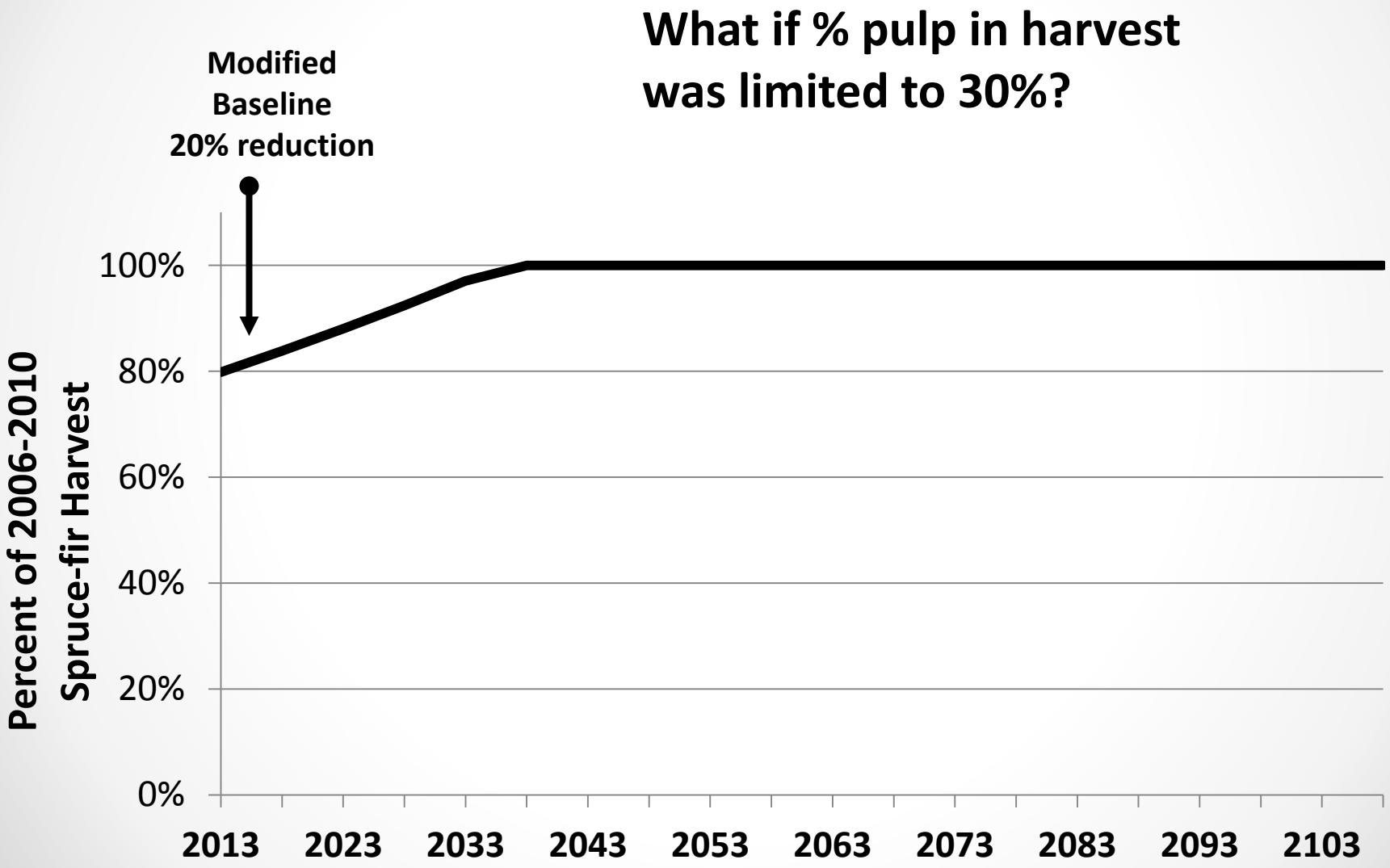
Maine Wood Supply Impacts – Historic Outbreak Replay

- Spruce-fir harvest may be maintained with limited foliage protection if:
  - Harvest prioritizes severely impacted stands before extensive mortality.
  - Harvest is not increased at the outset of the outbreak to capture salvage volume.
  - Clearcut/salvage operations can occur with relaxed operability standards: ≥50 m^3/ha (750 ft^3/ac) host species required.
  - Log : pulp ratios are permitted to decline from 75% (current) to ≈60%.
  - Spatial, habitat, or other important constraints like road access are not of concern.

- Meeting all of the above conditions is probably unlikely.

- What if % pulp in harvest was limited to 30%?

Maine Wood Supply Impacts – Historic Outbreak Replay



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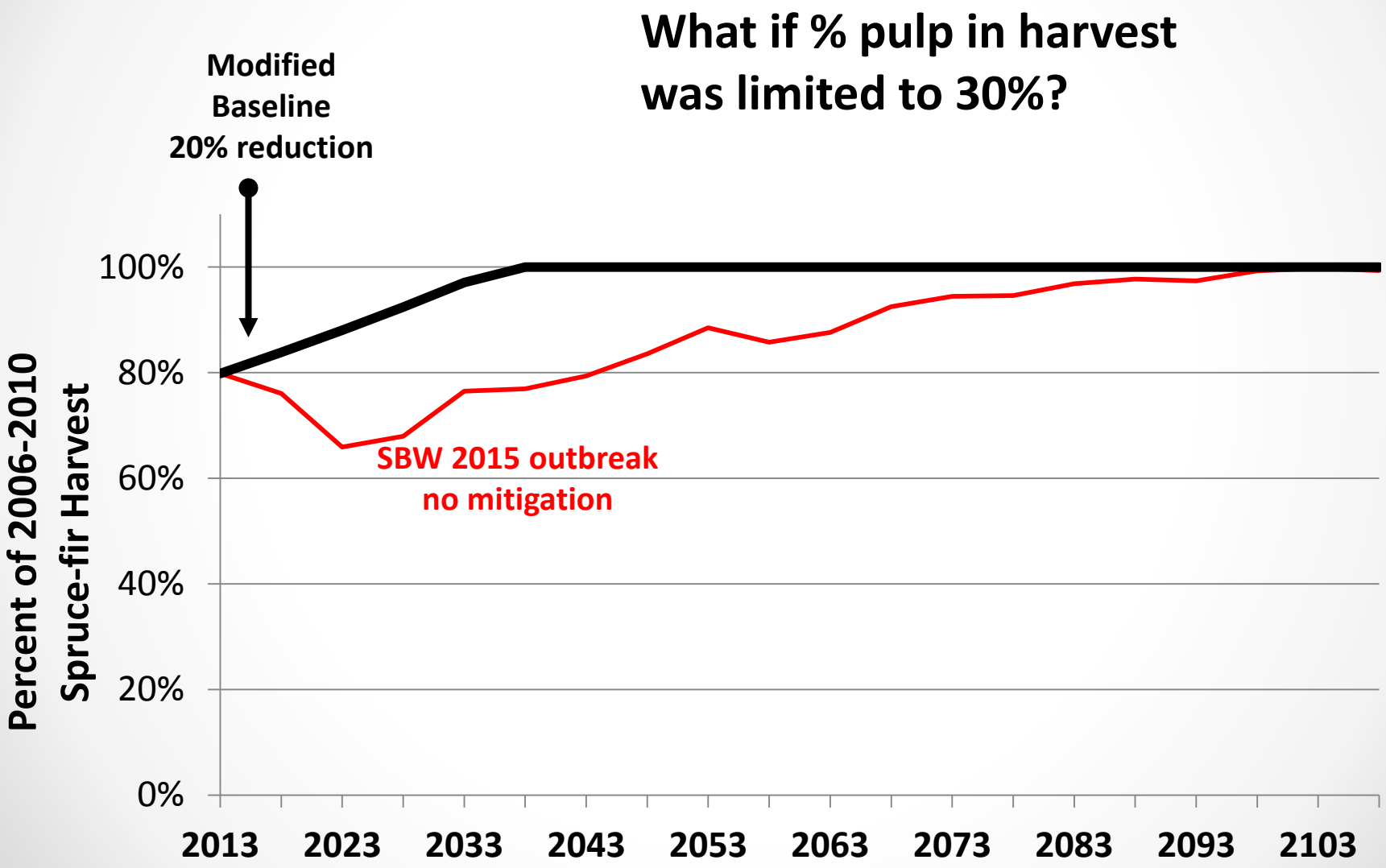

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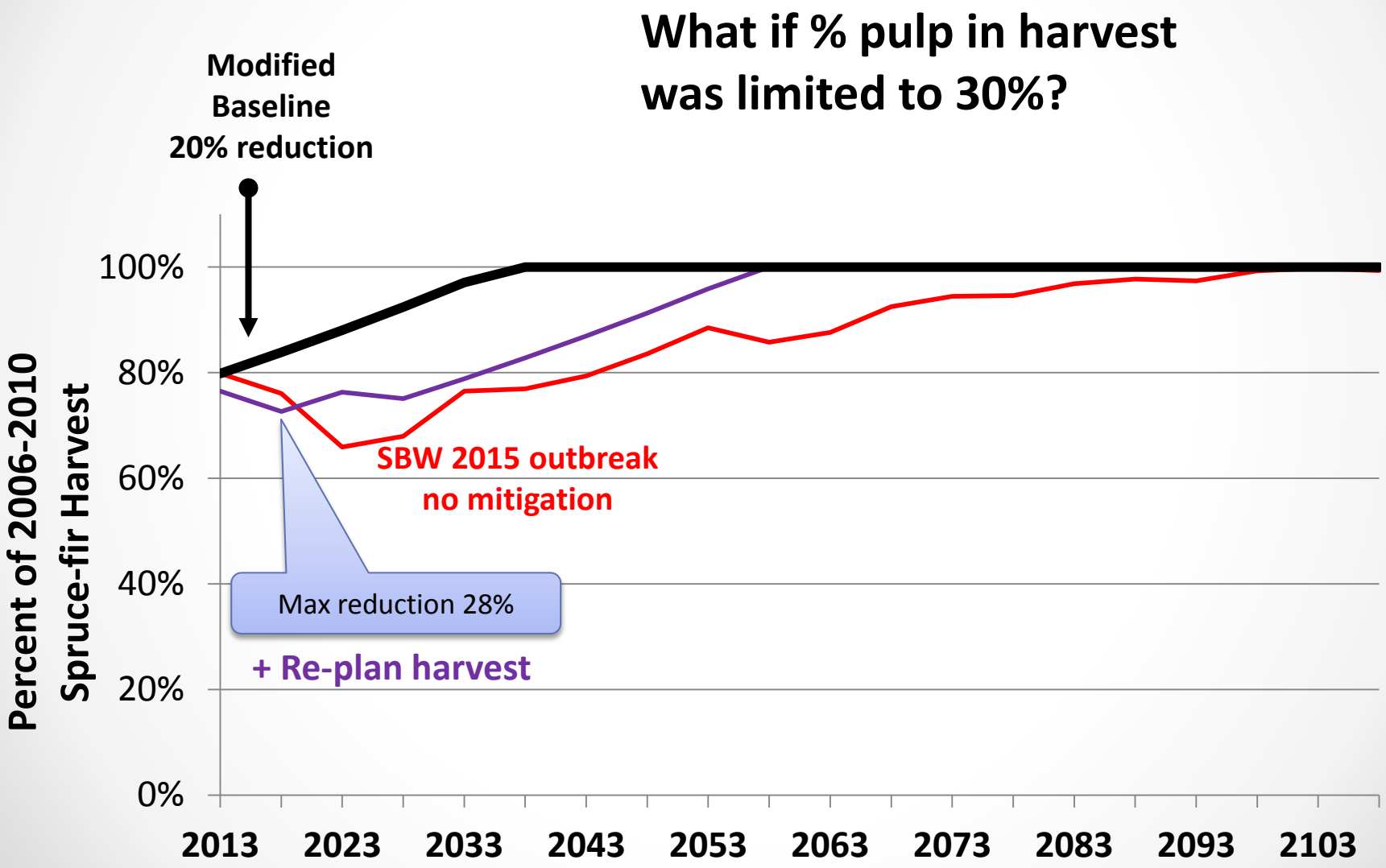

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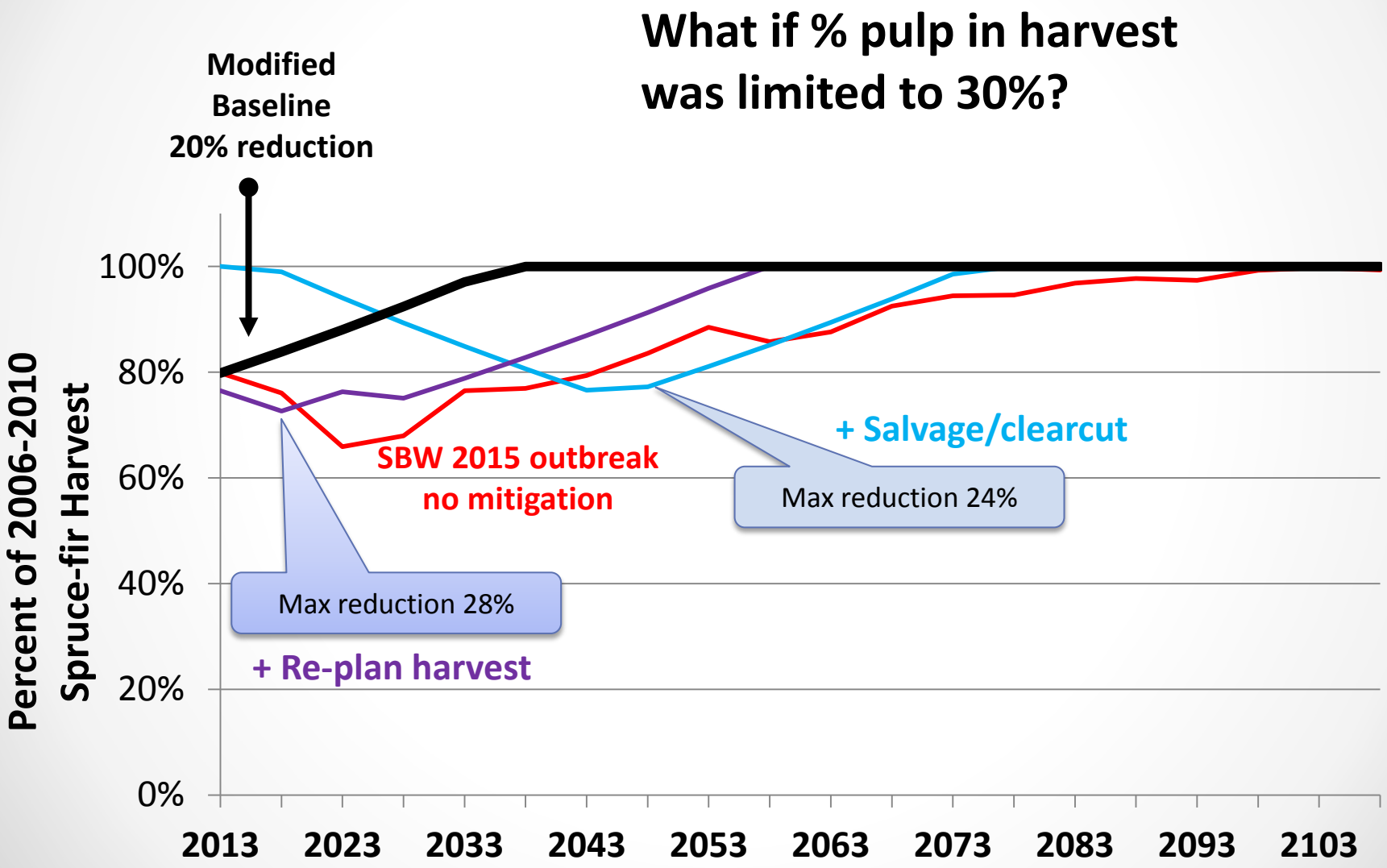

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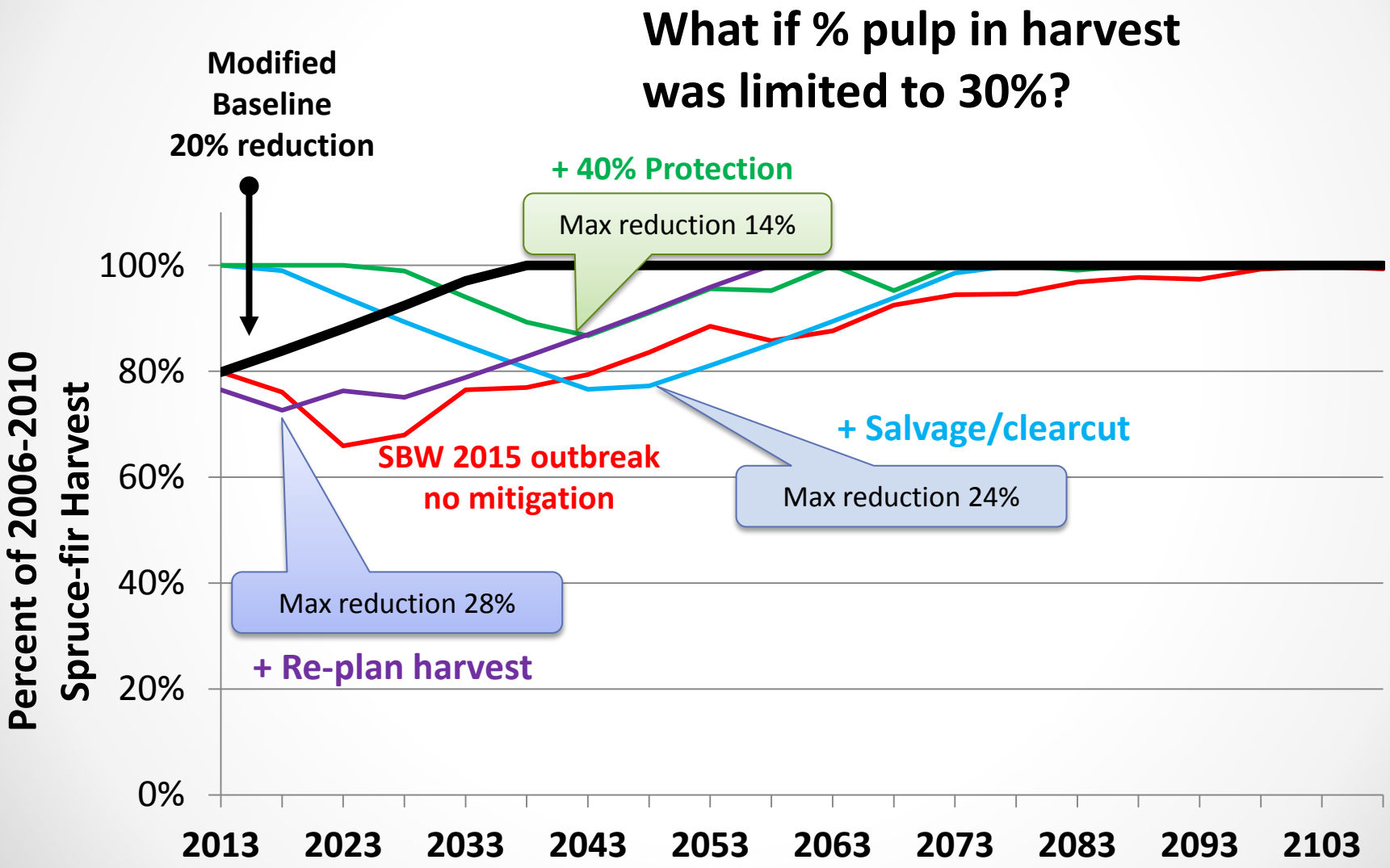
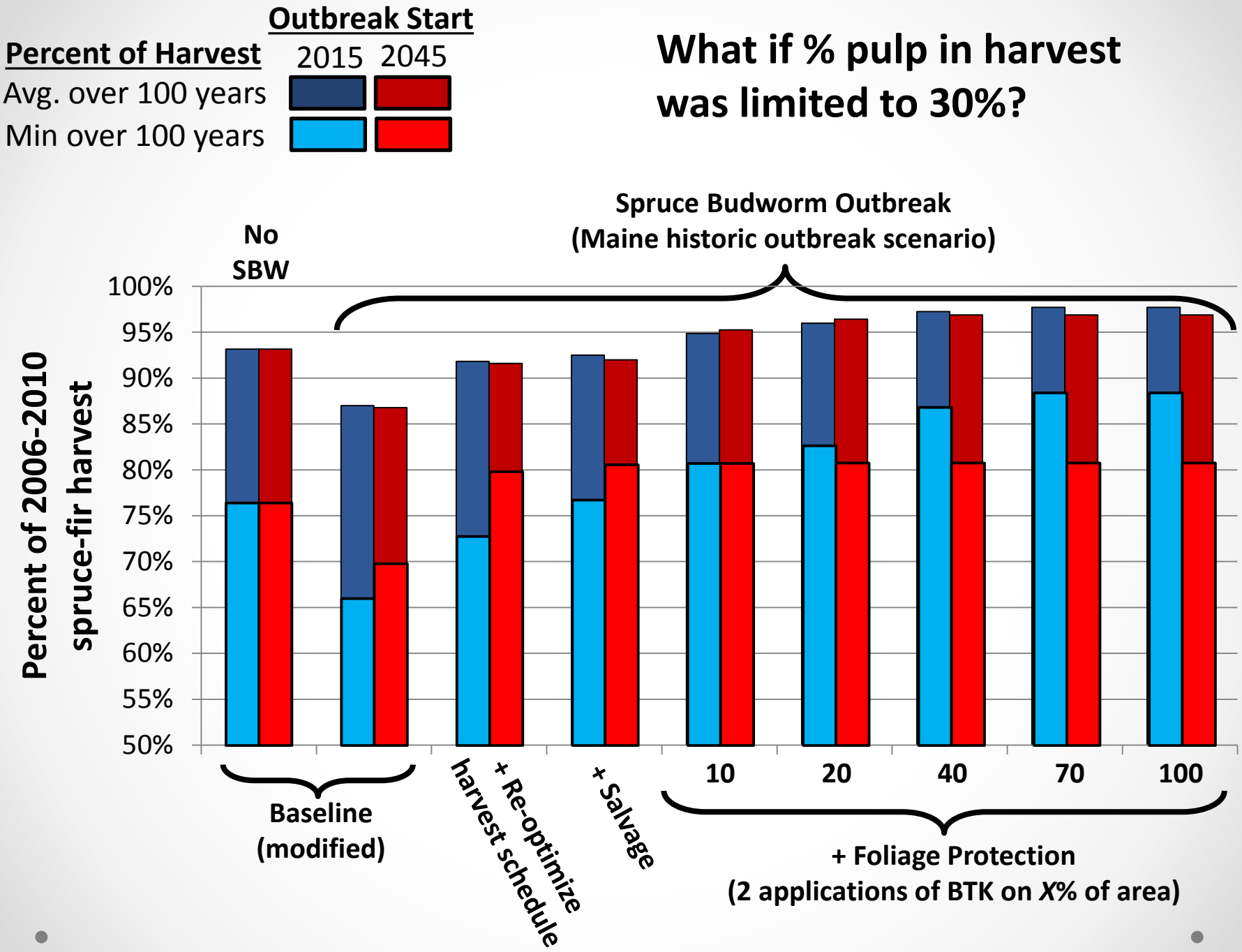


What if % pulp in harvest was limited to 30%?



Maine Benefit : Cost of Protection

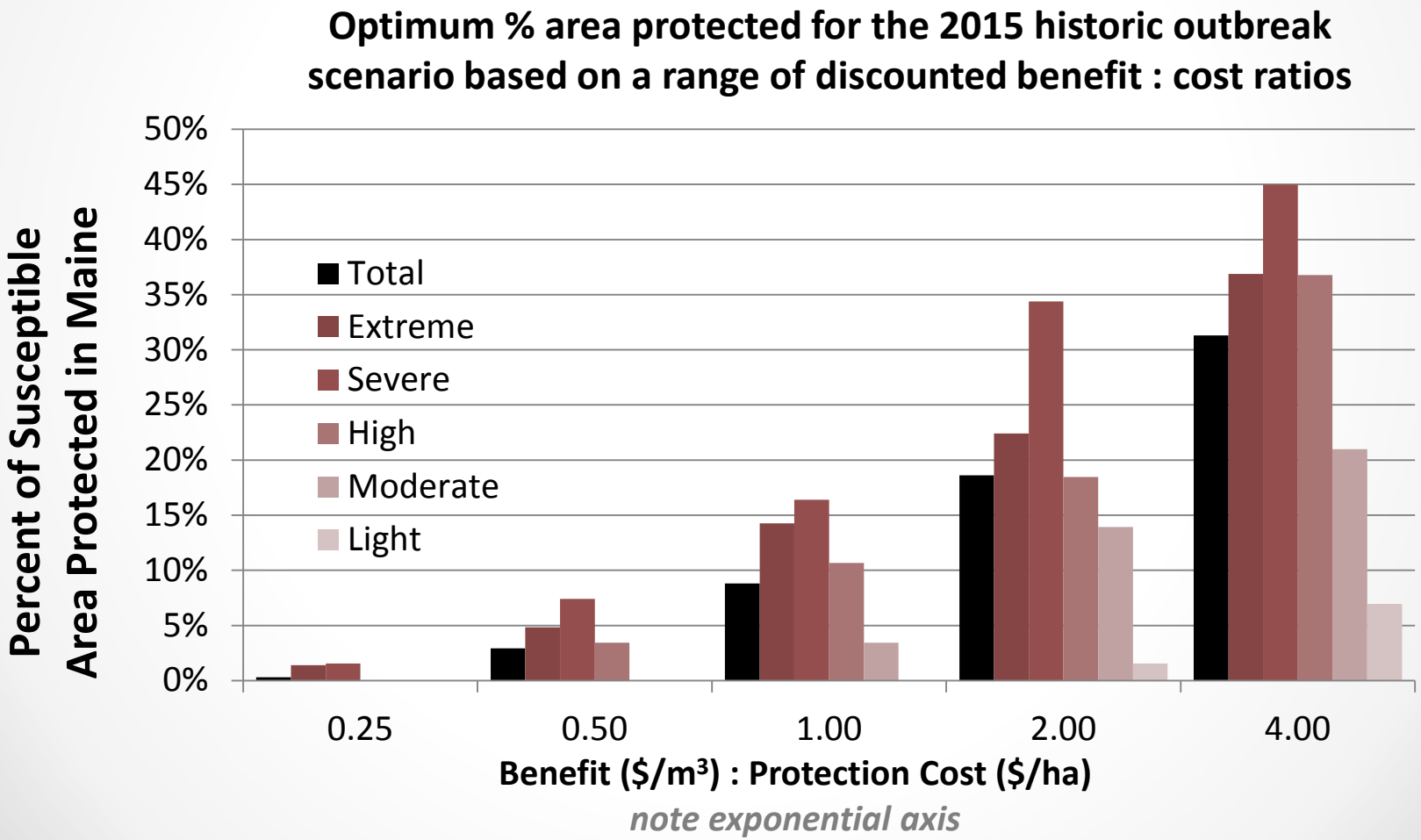
- Recent SBW economic impact study in New Brunswick:
  Chang, Lantz, Hennigar, MacLean. 2012. J. Econ. For.

  - Suggests protection of 10% landbase was optimum in terms of maximizing the discounted benefit : cost ratio of a SBW protection program.

  - With consideration of cross-sector GDP impacts in New Brunswick, benefit : cost ratios of such a protection program were estimated to be between 3 and 4.

  - Inclusion of non-market values generally increased the benefit-cost ratios and net present values of the control programs, and in some cases, led to higher levels of control being supported.

This wood-supply impact model can be used to better understand the value and amount of protection that may be appropriate for Maine.



Closing Thoughts

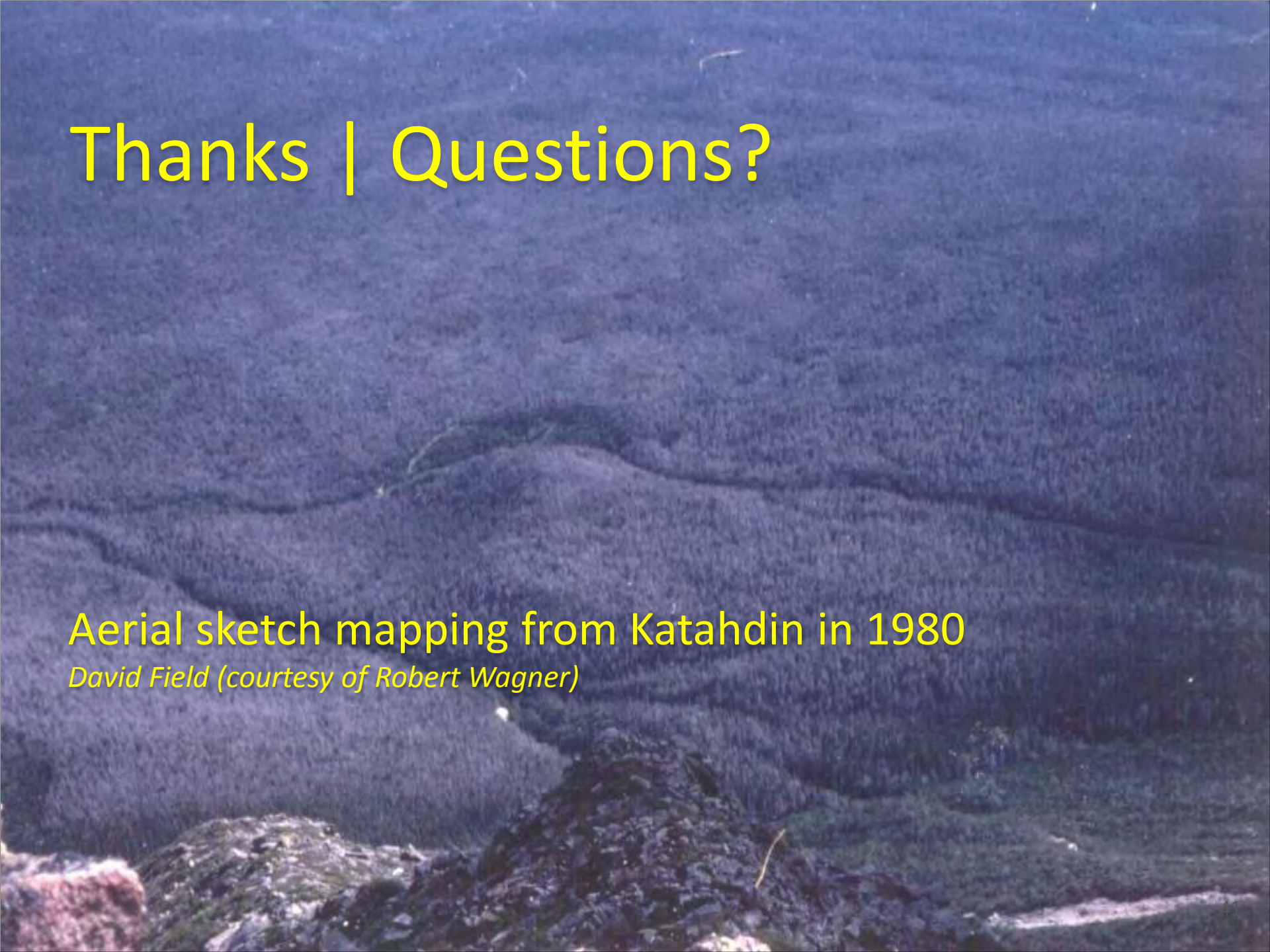
- Impacts and appropriate responses will differ among landowners:
  - Those with unallocated spruce-fir growing stock may depend more on salvage than foliage protection compared to landowners that require every available hectare to sustain their current or planned harvest.
  - Being able to adjust harvest plans to target severely impacted stands before mortality occurs is key.
  - To sustain harvest post outbreak, spruce-fir stands experiencing low impact (by chance) should be retained as long as possible.

Closing Thoughts

- Impacts on harvest is one issue:
  - What about loss of late successional spruce-fir communities on the landscape?
  - Will protection be needed in these reserve/sensitive areas to avoid downstream effects on harvest through non-timber management objectives?

- Perceived impacts and optimal response strategies are extremely sensitive to salvage standards.
  - Ability to salvage/clearcut over large areas would reduce the need for protection.
  - Will the state of Maine allow such treatments to occur?
  - Does increased cost of sub-merchantable / low quality salvage wood out-weight the cost of protection?

Thanks | Questions?



Aerial sketch mapping from Katahdin in 1980

David Field (courtesy of Robert Wagner)