DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

Development and Deployment of a Short Rotation Woody Crops Harvesting System Based on a Case New Holland Forage Harvester and SRC Woody Crop Header

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Terrestrial Feedstocks

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Goal Statement

- Develop, test and deploy a single pass cut and chip harvester combined with a handling, transportation and storage system that is effective and efficient in a range of different short rotation woody crop (SRWC) production systems, environments and conditions.
- Fits with terrestrial feedstock goals:
  - (1) reducing the delivered *cost* of sustainably produced feedstock
  - (2) preserving and improving the *quality* of harvested feedstock to meet the needs of biorefineries and other biomass users

Project Partners
Manufacturers - Growers - Consumers

ESF
State University of New York
College of Environmental Science and Forestry

NEW HOLLAND
AGRICULTURE

GREENWOOD
RESOURCES
A Resource That Lasts Forever™

Mesa
Reduction Engineering & Processing, Inc.

ZeaChem

Applied
Biorefinery
Sciences

Funding Support

US Department of Energy – Biomass Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BIOMASS PROGRAM

NEWBio

New York State Energy Research and Development Authority

nyserda

Energy. Innovation. Solutions.

USDA United States Department of Agriculture National Institute of Food and Agriculture

NYSTAR - Technology Transfer Incentive Program

NYSTAR®

Empire State Development
Division of Science, Technology & Innovation

Quad Chart Overview

Timeline

- Project start date: August 2010
- Project end date: August 2014
- Percent complete: 100%

Budget

	Total Costs FY 10 –FY 12	FY 13 Costs	FY 14 Costs	Total Planned Funding (FY 15-Project End Date
DOE Funded	$759,596	$573,889	0	0
Project Cost Share (Comp.)*	$1,171,161	$293,157	0	0

Barriers

- Barriers addressed
  - Ft-A Terrestrial Feedstock Availability and Cost
  - Ft-E Terrestrial Feedstock Quality and Monitoring
  - FT-I Biomass Material Handling and Transportation

Partners

- SUNY-ESF – Project lead/ Willow harvesting
- Case New Holland - OEM
- Greenwood Resources – Hybrid poplar growth and harvesting
- Mesa– transportation/logistics
- Zeachem and Applied Biorefinery Sciences – biorefinery partners

1 - Project Overview - Harvesting Challenges

- Harvesting is 30-40% of delivered cost of SRWC (Buchholz and Volk 2011)
- Harvesting is the 2nd largest source of GHG emissions (Heller et al. 2003)
- Commercial SRWC markets are developing but lack of reliable harvesting systems that produce consistent quality chips is a barrier
- Harvester throughput and header feeding issues
  - Inconsistent chip size and quality
  - Equipment reliability
- Multiple systems tested over the years

2 - Approach (Technical)

- Team of crop production experts, equipment engineers and operators, biorefinery partners collaborated so multiple concerns and objectives are met simultaneously
- Iterative optimization of New Holland short rotation coppice header for willow and hybrid poplar
  - Engineering and development of specialized cutting head
  - Field testing in willow and hybrid poplar crops with monitoring of system performance and chip quality
  - Modify/improve system and conduct field tests

2 - Approach (Management)

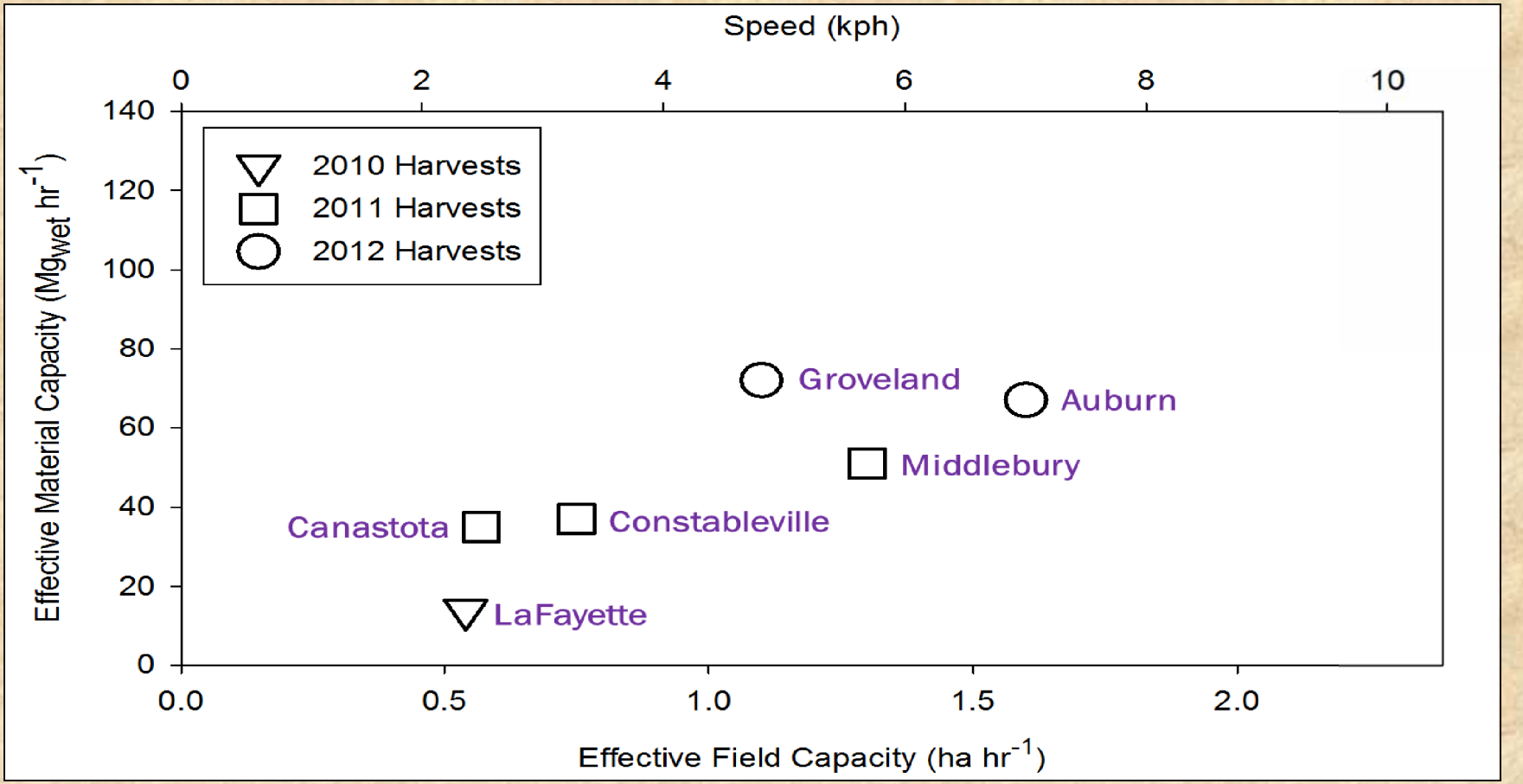
- Critical success factors
  - Develop reliable system that produces consistent quality chips from SRWC systems that are acceptable to end users
  - Reduce the cost of harvesting by 25% or more
  - Reduce barrier to commercial deployment of SRWC associated with harvesting system reliability and quality of biomass
  - Harvesting system readily available to producers with support and service network
- Four Main Tasks
  - Task 1 - Harvesting and Equipment
  - Task 2 - Collection Systems
  - Task 3 - Chip Quality
  - Task 4 - Assess Economics / Cash Flow Modeling

3 – Technical Accomplishments/ Progress/Results

Harvesting Equipment in this Project

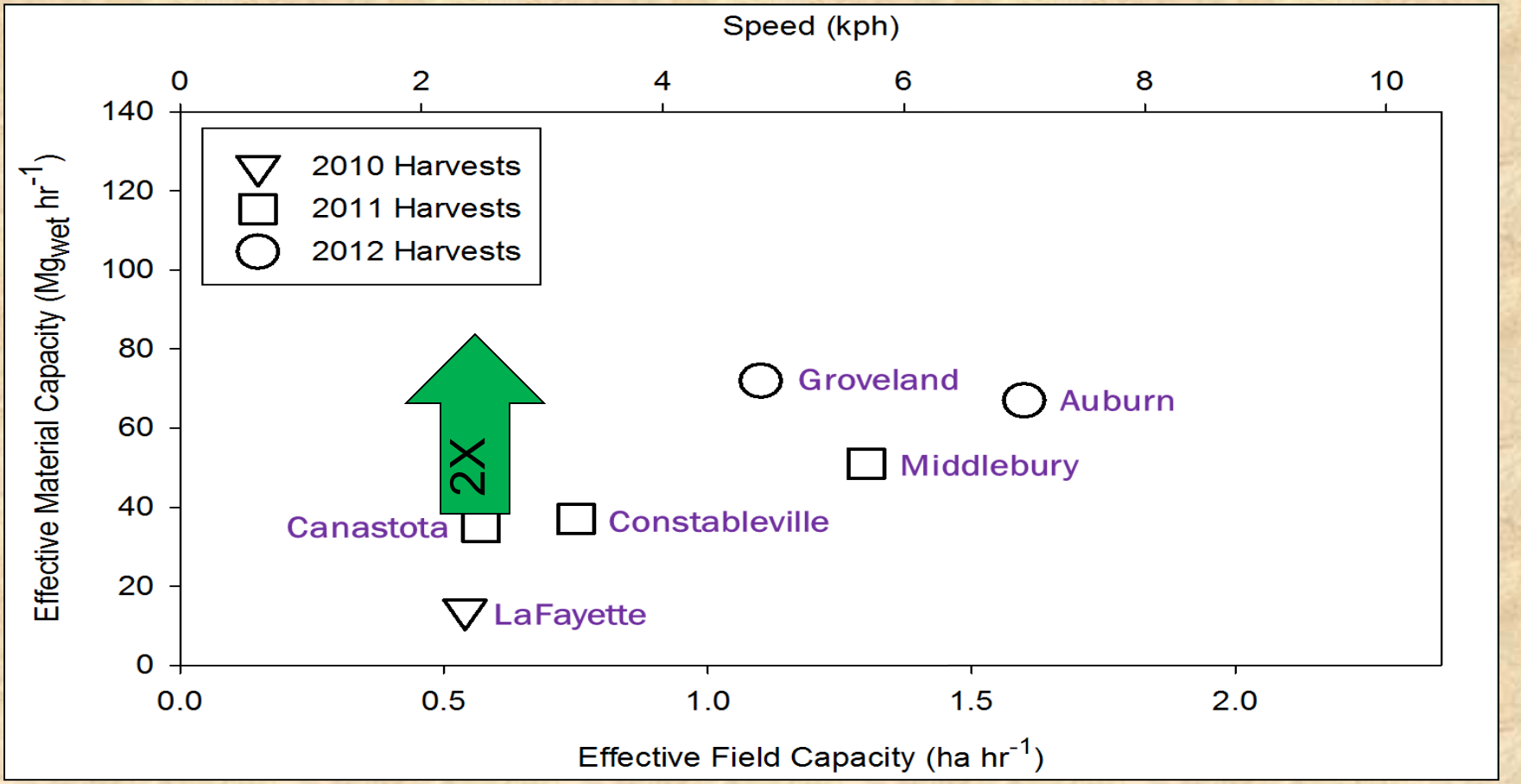
- New Holland FB-130 Coppice Header
- Designed to fit New Holland 9000 and Forage Cruiser series of forage harvesters

Willow Harvesting Trials



- 8 different willow biomass crop and 5 hybrid poplar harvests (not shown here)

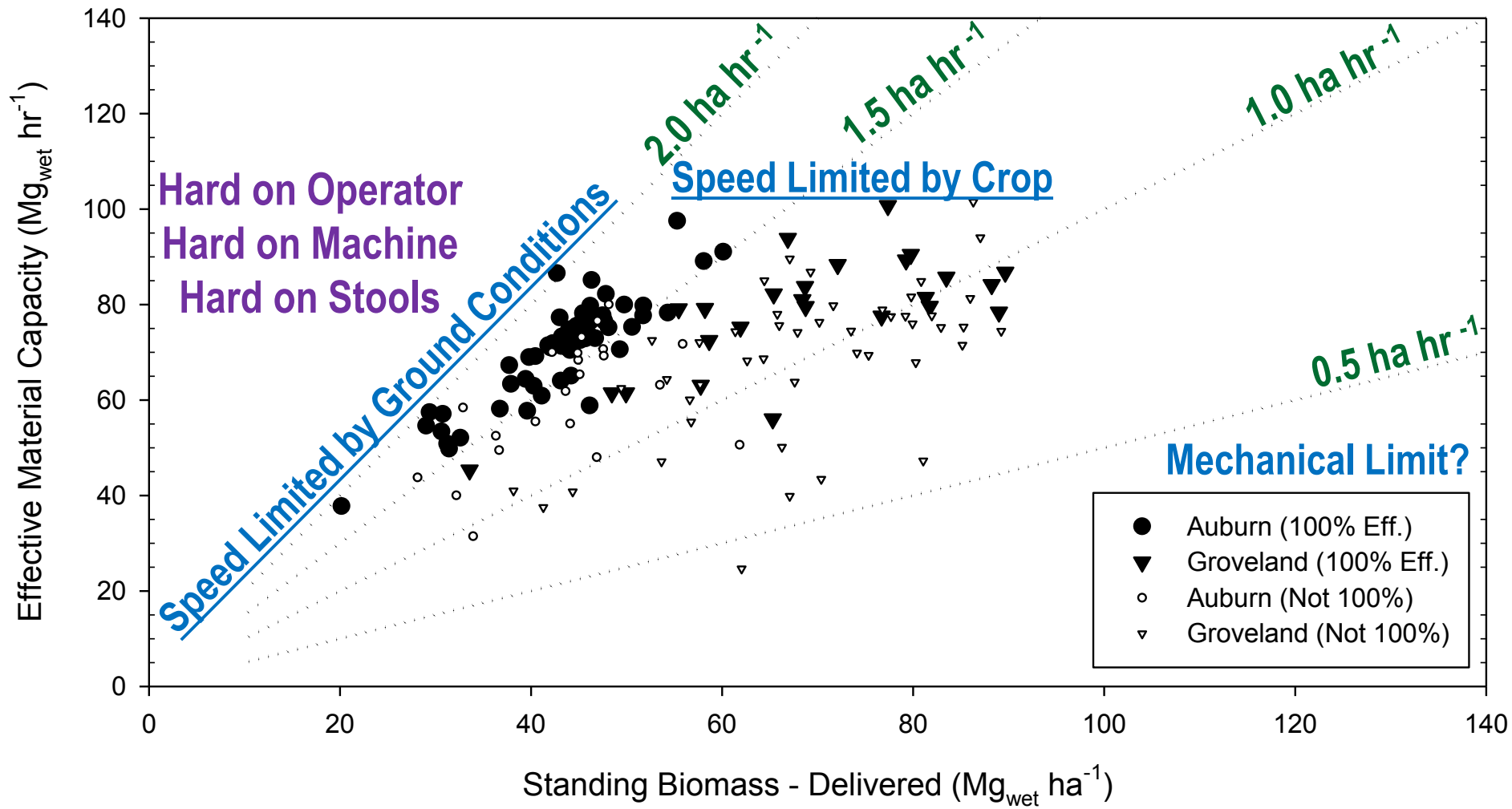
Willow Harvesting Trials



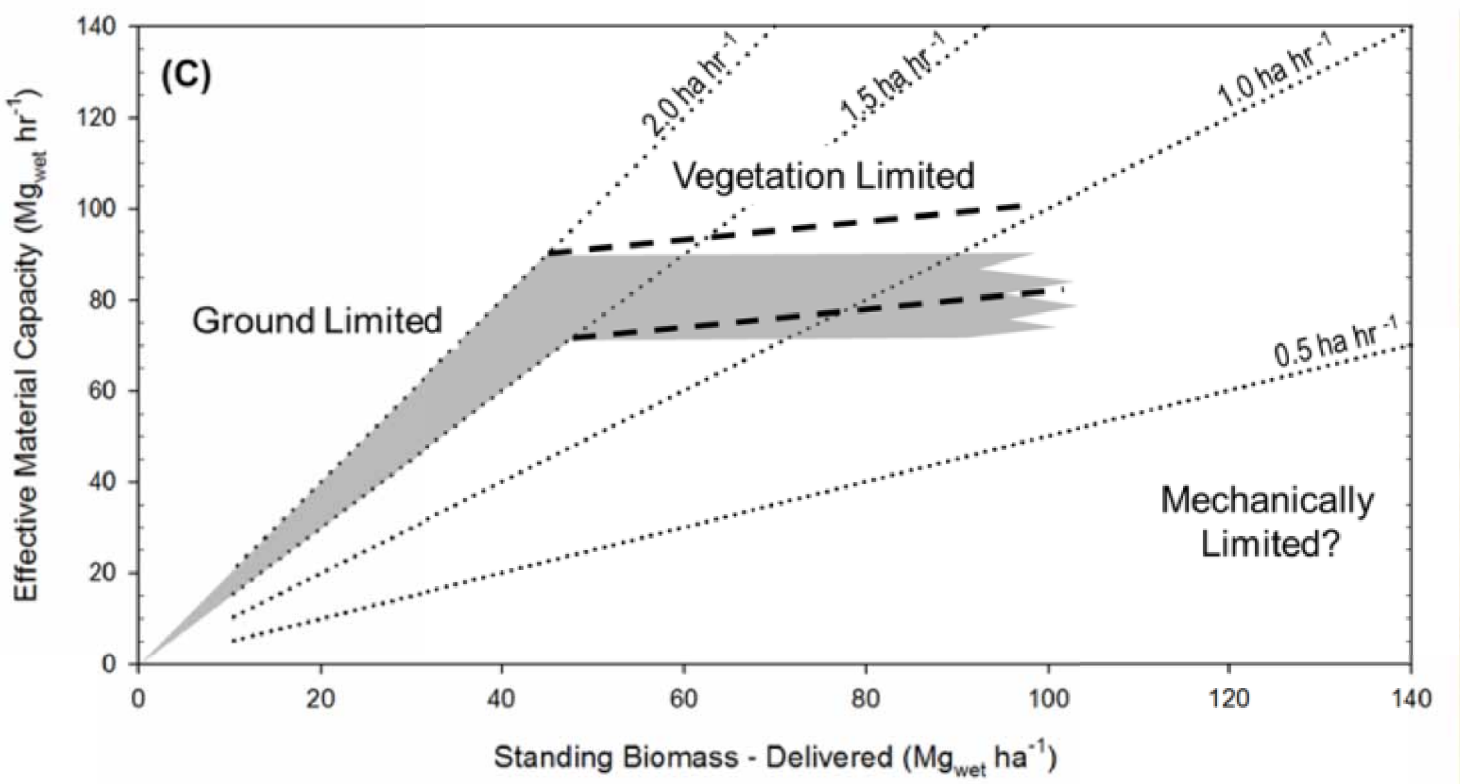
- 8 different willow biomass crop and 5 hybrid poplar harvests (not shown here)

Harvester Performance In Willow Fields

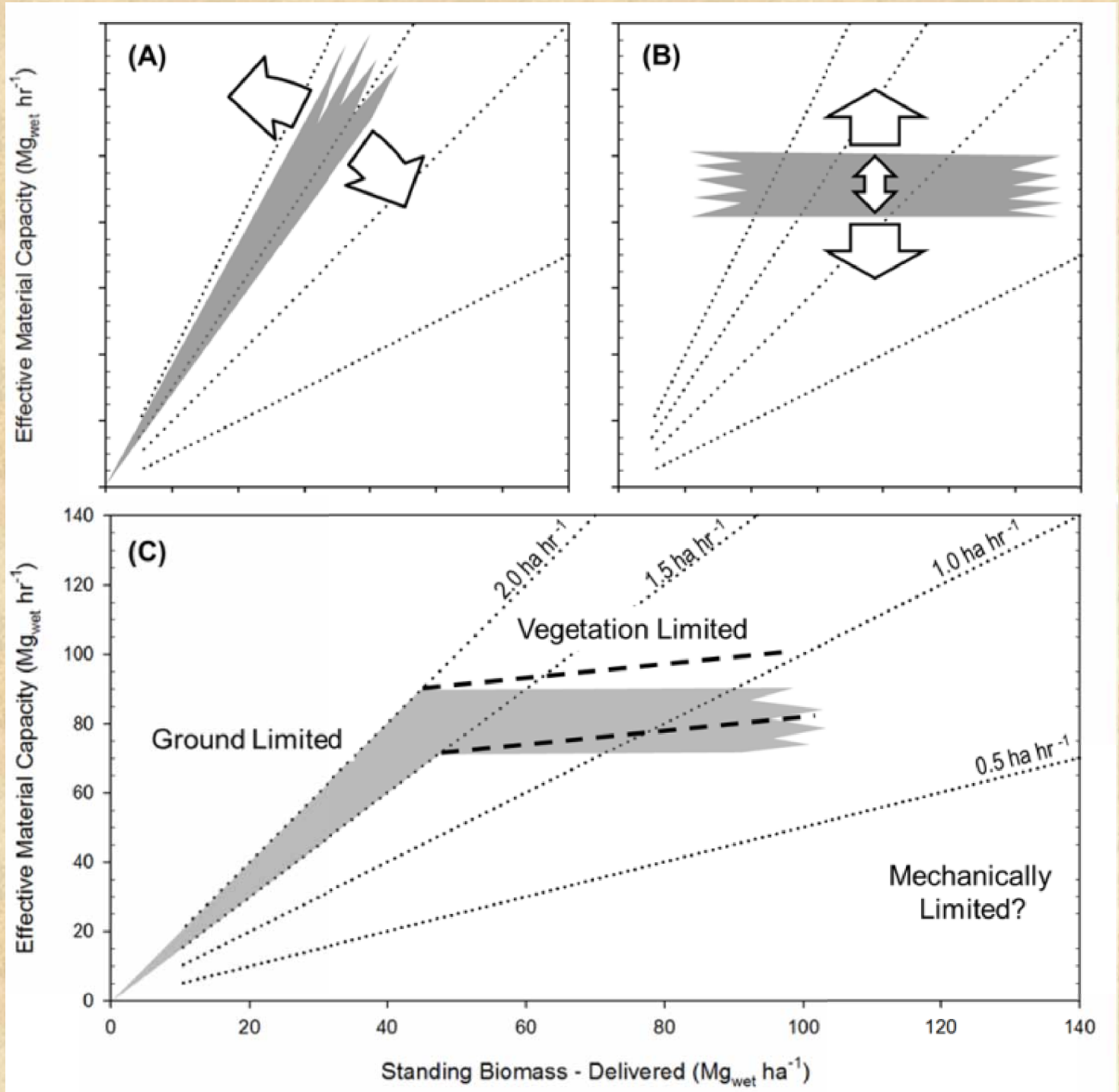
- Standing biomass limits speed over 40-45 Mg ha^{-1}
  - i.e. Harvester could not go 2 ha hr $^{-1}$ in 80 Mg ha^{-1}



Harvester Performance In Willow Fields

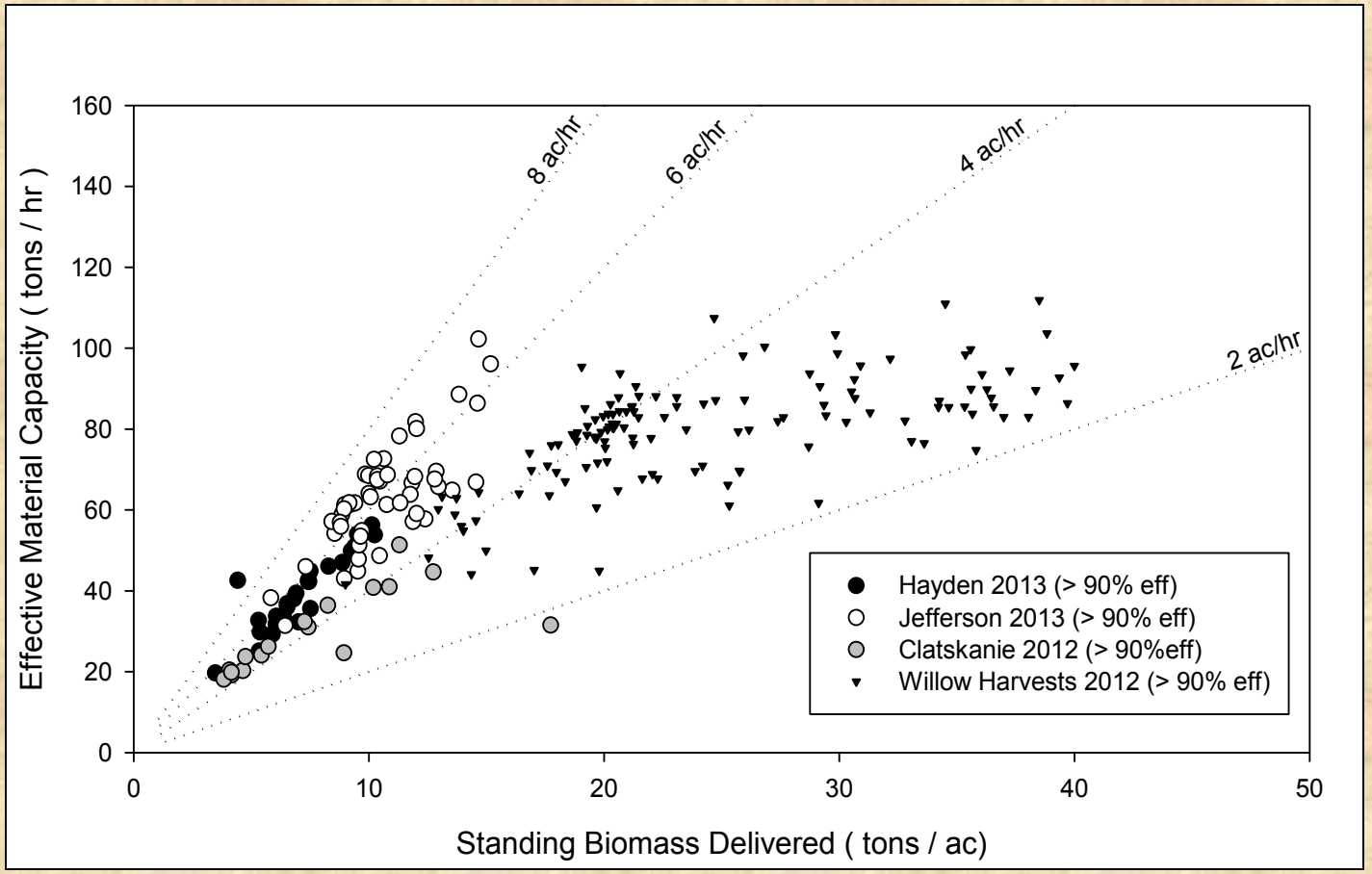


(Eisenbies et al. 2014)



(Eisenbies et al. 2014)

Hybrid Poplar Harvests



Hybrid poplar harvests (large circles) suggest that there is a different pattern in the shape of the curve compared to willow

System Performance



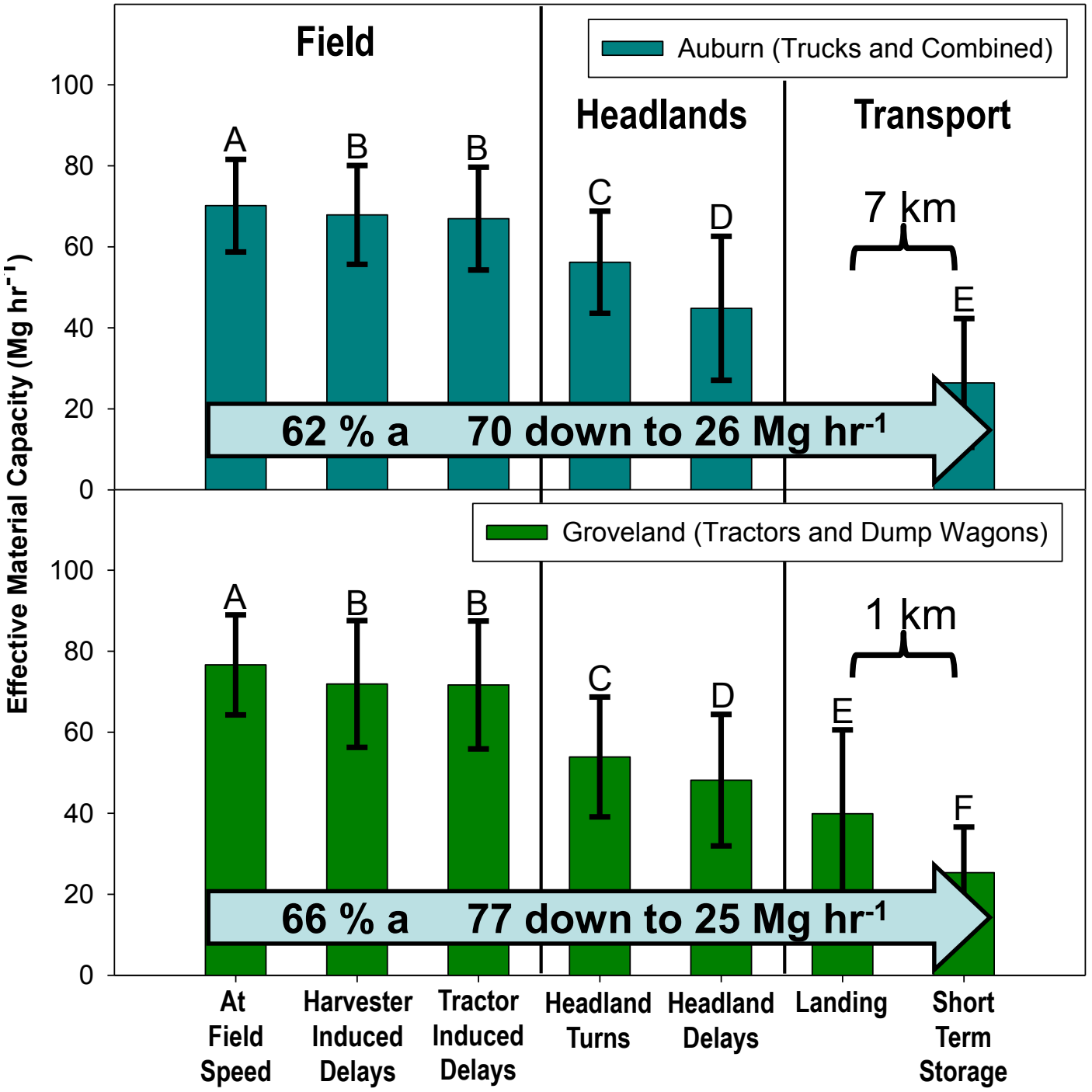



- A variety of different collection vehicles were tried during harvesting operations

System Performance

"Out the Spout" to Storage

62-66% loss of efficiency overall

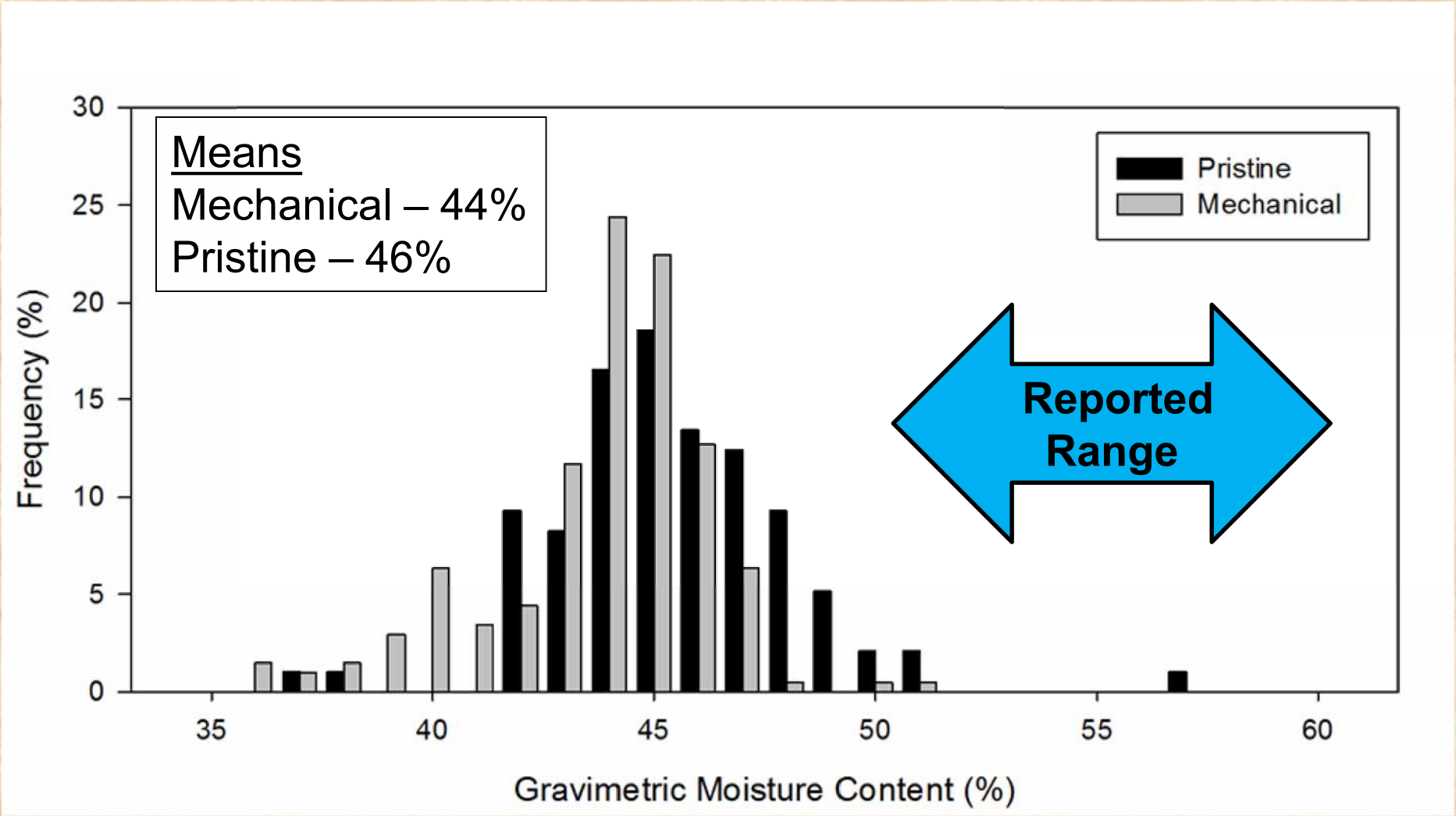


What About Chip Quality?

Importance of Biomass Quality

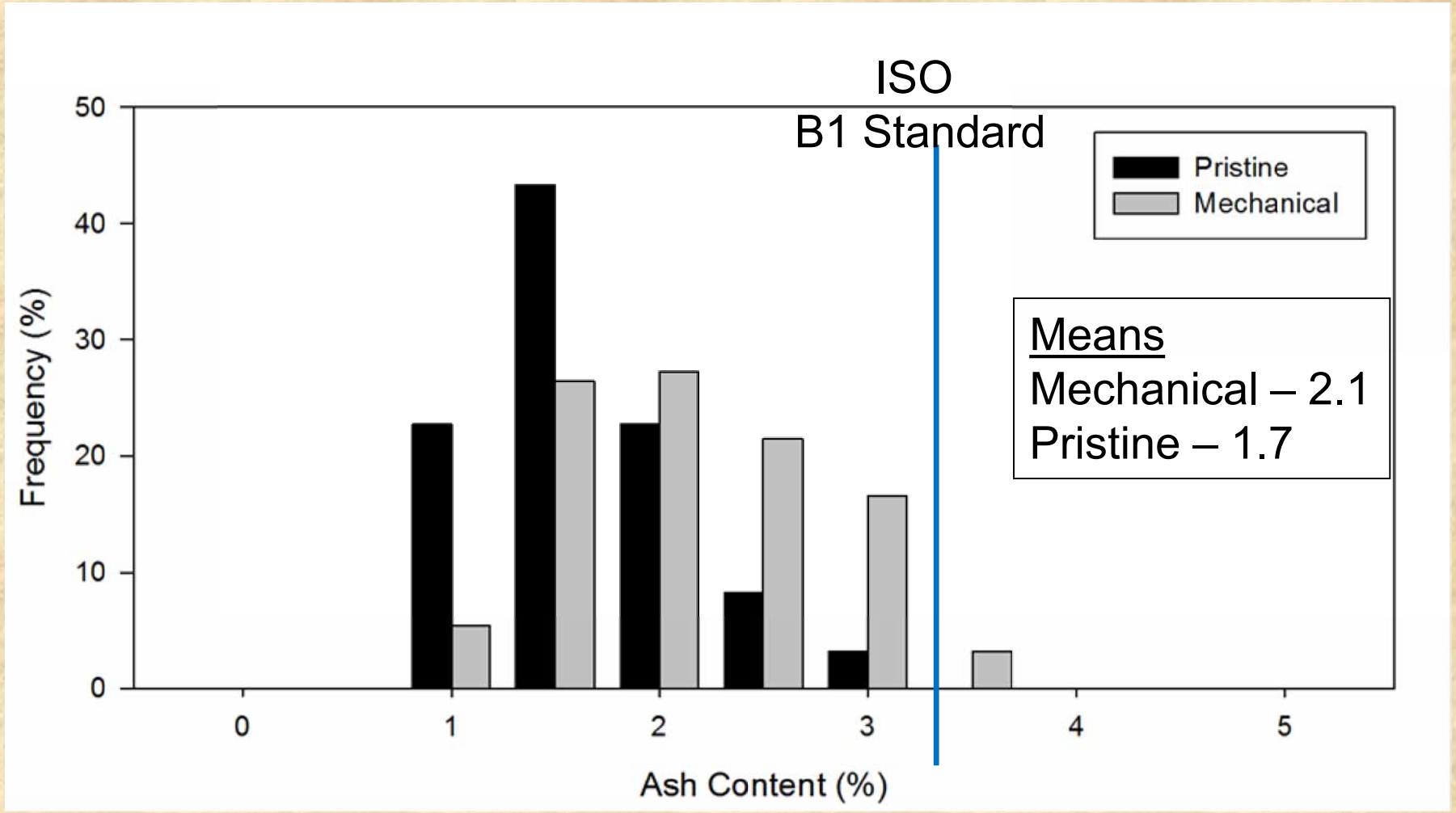
- Focus has often been on cost per ton rather than the quality of the biomass
- Differences in quality of hand harvested, pristine research samples and field harvested material
- Field harvested and stored material is generally more variable for a range of characteristics (i.e moisture, ash, energy, sugar content etc.)
- Increased variability creates challenges for end users
- Over 200 samples and associated data from large scale harvesting shared with Idaho National Laboratory for Bioenergy Library

Moisture Content



Frequency distribution of moisture content of 205 samples of willow collected during harvesting (Eisenbies et al. 2014b)

Ash Content



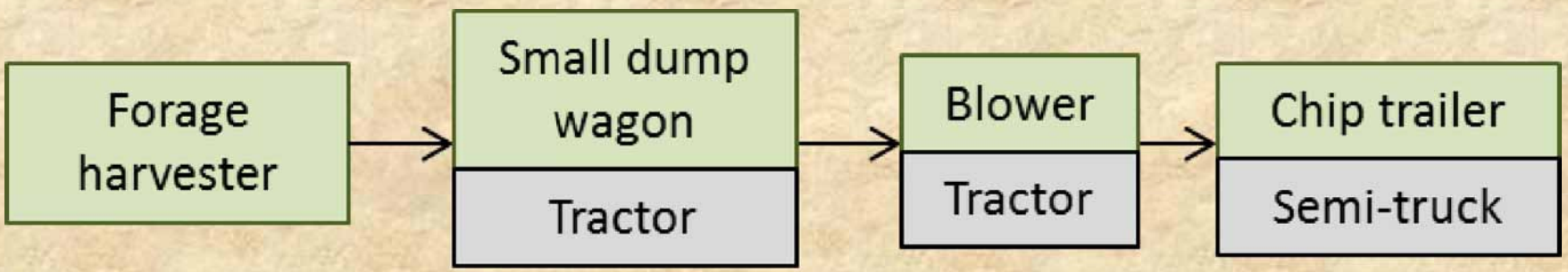
Frequency distribution of ash content of 224 samples of willow collected during harvesting (Eisenbies et al. 2014b)

Particle Size Distribution

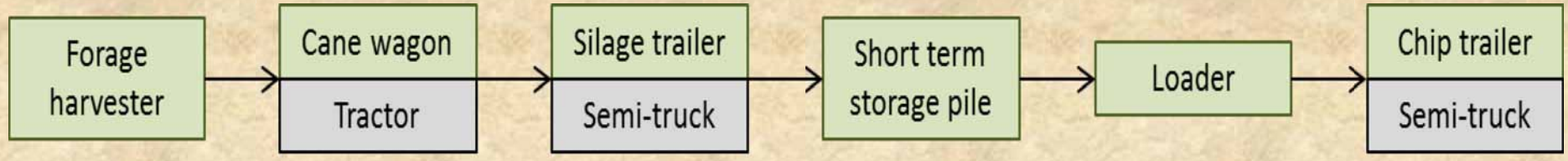
- Over 96% of the chips were between 6 and 45mm in size
- Less 0.5% were >45mm
- About 3.5% were less than 6mm
- ISO Standard P45S requires that >60% of the chips are between 3.15 and 45mm

Economics of Willow Harvesting System

Base Case Scenario



Advanced Case Scenario



(Webb et al. 2013)

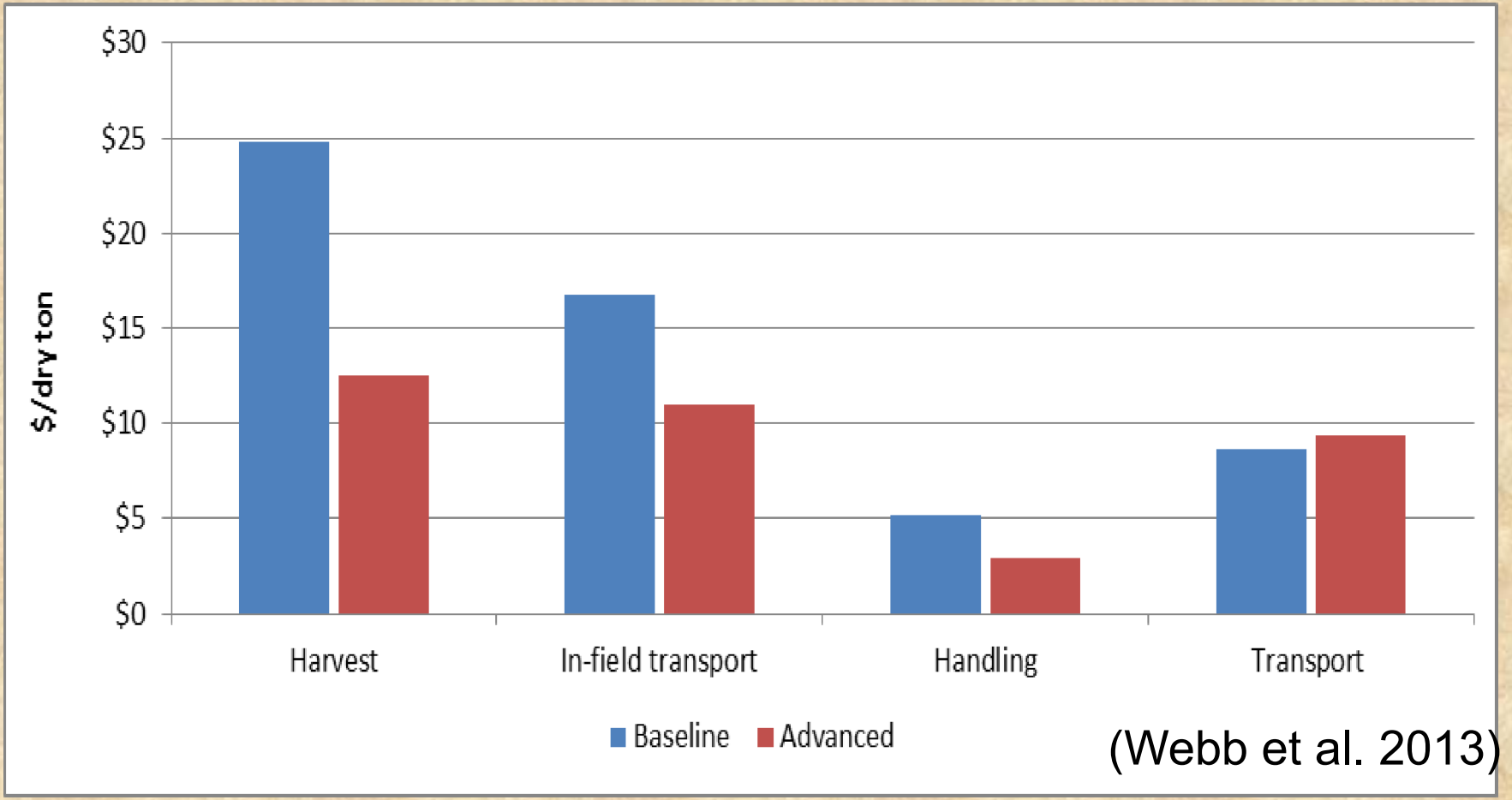
ECONOMICS

- Provided input for staff at Oak Ridge National Lab to run IBSAL model for a 800,000 Mg_{dry} $year^{-1}$ biorefinery in upstate New York
- Willow is harvested and supplied directly to the biorefinery from October to early April
- For the remainder of the year, the conversion facility uses low-grade woody residues
- Assuming that willow supplies the conversion facility for 26 weeks per year, the feedstock supply system is scaled to deliver 400,000 dry tons/year
- Material comes from a 28 mile radius

Two Harvesting Scenarios

- Base Case
  - Based on harvesting trials in 2010
  - Harvester efficiency was 74%
  - Harvester speed was 2.5 kph
  - Transfer of chips from wagons to trucks using silage blower
- Advanced Case
  - Based on harvesting trials in 2012/13
  - Harvester efficiency was 95%
  - Harvester speed was 4.5 kph
  - Transfer of chips from wagons to silage trucks, then deposited in short term storage and reloaded with a bucket loader

Changes in Harvesting Costs



(Webb et al. 2013)

- Overall cost dropped from \$52 to \$34/Mg_{dry}, a 35% reduction

Equipment Availability

- 130 FB coppice header available from New Holland and highlighted in NH materials
- Supported by network of New Holland dealers across the U.S.

4 – Relevance

- Improved reliability and efficiency of harvesting system
- Produced chips of consistent quality over hundreds of loads and characterized the material
  - ReEnergy Holdings has used several thousand tons of material and is mixing it in with it forest biomass supply
  - Have signed contracts to purchase all the willow biomass from 1,200 acres in northern NY
- Reduced harvesting costs by about 35%
- Harvesting equipment for SRWC now available from New Holland and supported by network of dealers
  - Harvester purchased by growers in northern NY that are managing almost 500 ha of willow
  - Assessment for another unit ongoing for hybrid poplar coppice in the Pacific Northwest

Summary

- Single-pass cut-and-chip harvester that is effective in SRWC in North America is now commercially available from New Holland
- Harvester has improved throughput and efficiency, which has contributed to important cost reductions
- Quality of SRWC biomass from large scale harvests has a low degree of variability, is consistent across many loads, and meets ISO wood chip standards
- Development and deployment of single pass harvesting system has provided confidence for growers to expand SRWC acreage and for end users to commit to using the biomass produced
  - End users have signed long term contracts for material

5 – Future Work

- Recently awarded new project to further reduce the delivered cost of woody crops on both the east and west coast by:
  - Improving harvester operations so period of time when harvesting is possible can be expanded
  - Optimizing collection and delivery systems using an iterative process of modeling and field trials
- Quality of the feedstock will be assessed along the entire supply chain and the impact of variations in key quality parameters on the yield of biofuels will be determined by our key biorefinery partners
- Further details provided in peer review meeting

Questions

Additional Slides

Publications, Patents, Presentations, Awards, and Commercialization

- Two peer reviewed publications completed, one more completing being reviewed by coauthors
  - Eisenbies, M.H., T.A. Volk, J. Posselius, C. Foster, S. Shi, and S. Karapetyan. 2014. Evaluation of a Single-Pass, Cut and Chip Harvest System on Commercial-Scale, Short-Rotation Shrub Willow Biomass Crops. BioEnergy Res. DOI 10.1007/s12155-014-9482-0
  - Eisenbies, M.H., T.A. Volk, J. Posselius, S. Shi, and A. Patel. 2014. Quality and variability of commercial-scale short rotation willow biomass harvested using a single-pass cut-and-chip forage harvester. BioEnergy Res. DOI 10.1007/s12155-014-9540-7
- Over 25 presentations at scientific meetings, field days, regional energy and biomass meetings, national bioenergy day etc.
- Two extension publications targeting general public developed and distributed
- Videos of harvesting operations made for general public