# Economic Impact of USWBSI's Research on Reducing FHB

**Keynote Presentation:** ***Drs. Wilson, McKee and Nganje***
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## Study Background

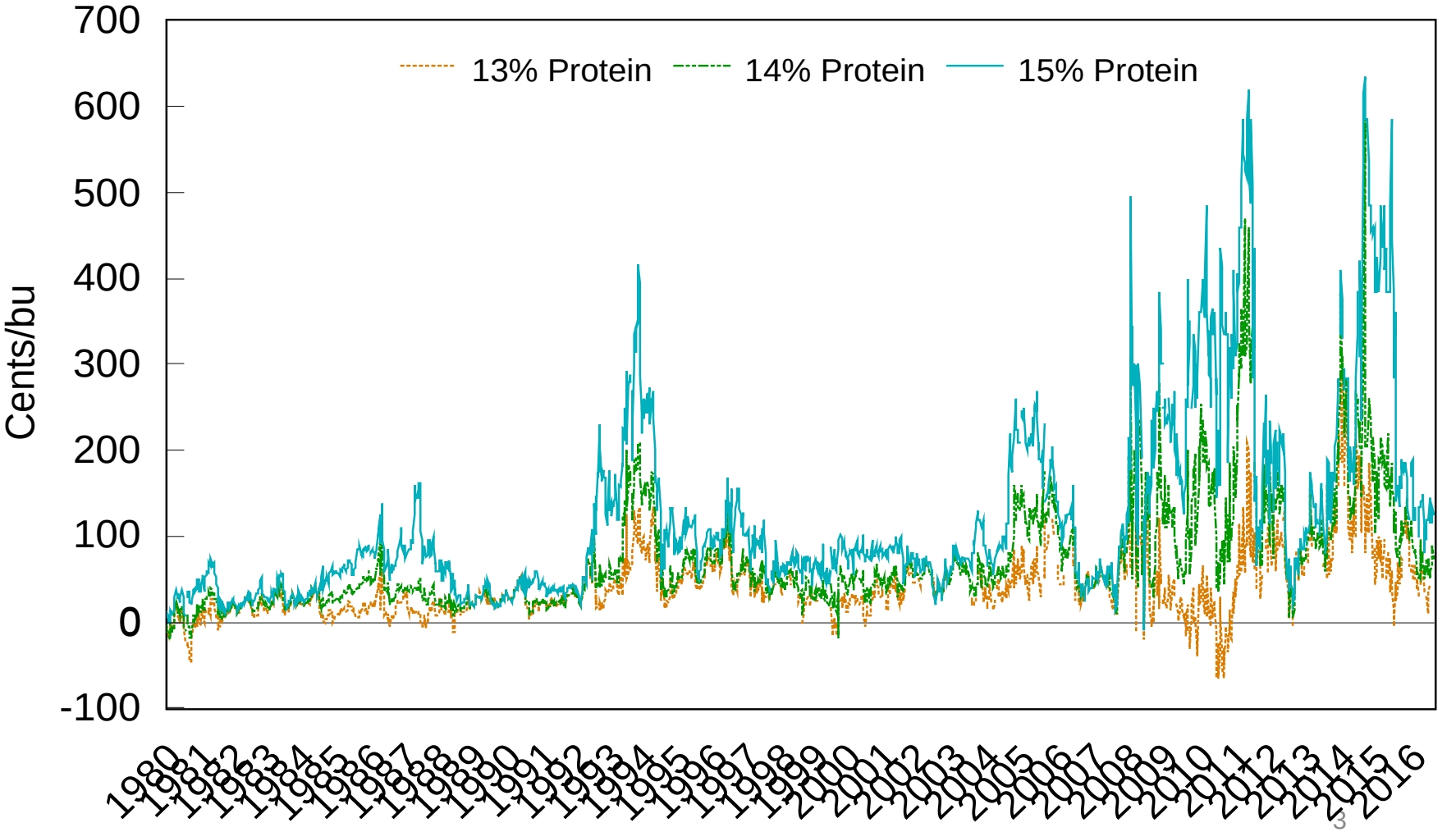
- **Purpose:** Estimate economic impacts of reducing FHB on cereal producers, traders and handlers and processors.
- Developed economic models, analyzed extensive data and conducted surveys of wheat flour millers, barley maltsters, and grain handlers.
- **Specific focus**
  - Costs of FHB,
  - Impact of mitigating strategies on yields and DON levels;
  - Marketing practices in the supply chain,
  - Impact of the SCAB initiative on reducing yield losses,
  - Return on investment of the SCAB initiative
  - Secondary impacts of the initiative.

## Organization

- Evolution of DON
- DON mitigation tools
- Statistical relations: DON, Yield and mgmt. strategies
- Risk and risk premiums
- Market mechanisms
- End-use survey
- Value of lost production
- Return on investment to re
- Summary and Implications
  - Industry Implications
  - SCAB Initiative

# Introduction

# Mpls. Spring Wheat Protein Spreads 1980-2016



# Evolution of DON

- **Evolution**
  - Escalation in importance since 1993
- **Breeding**
  - **Conventional**
    - Early resistance in HRS and barley
    - Later developed for SRW and HRW
  - **New Developments**
    - Emergence of alternative breeding technologies (GM, Gene-editing, cloned genes) may enhance resistance
    - GM technologies
    - Gene-Editing
    - Cloning of the resistance gene [Demaree (2016) Kansas State University]
- **Other management tools adopted**
  - Fungicide, crop rotations, DON forecasting models, etc.
- **CODEX:** proposal to tighten maximum limits on international shipments

## Growers

- Variety section and best management practices;
- Fungicide:  Toxin prediction, fungicide and increased sampling;
- Disease forecasting;

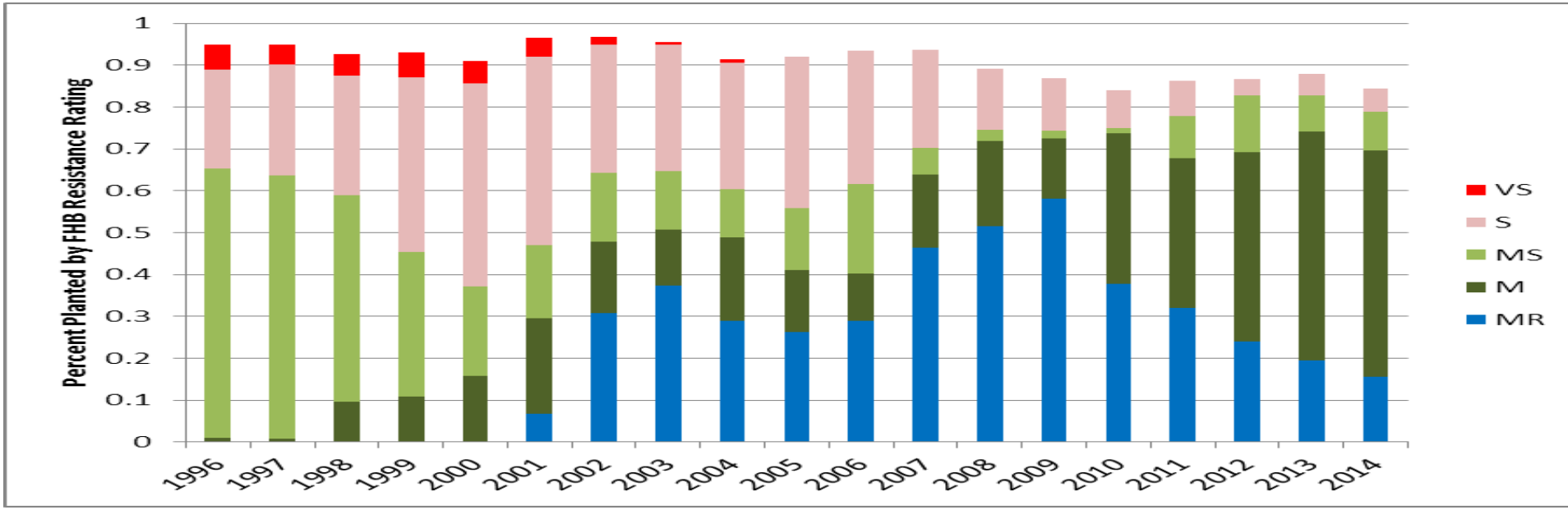
Source:  Bianchini, A., et. al.. 2015.

## Buyers/end-users

- Specification limits
  - Domestic
  - Importer
- Milling/malting pre-processing practices
  - Surveillance
  - Added costs:
    - Testing
    - Cleaning
    - Segregation
    - Discounts, etc.
  - Shift origins in epidemic years

# DON Mitigation

## HRS: Market share of Variety Adoption by FHB Resistance Rating

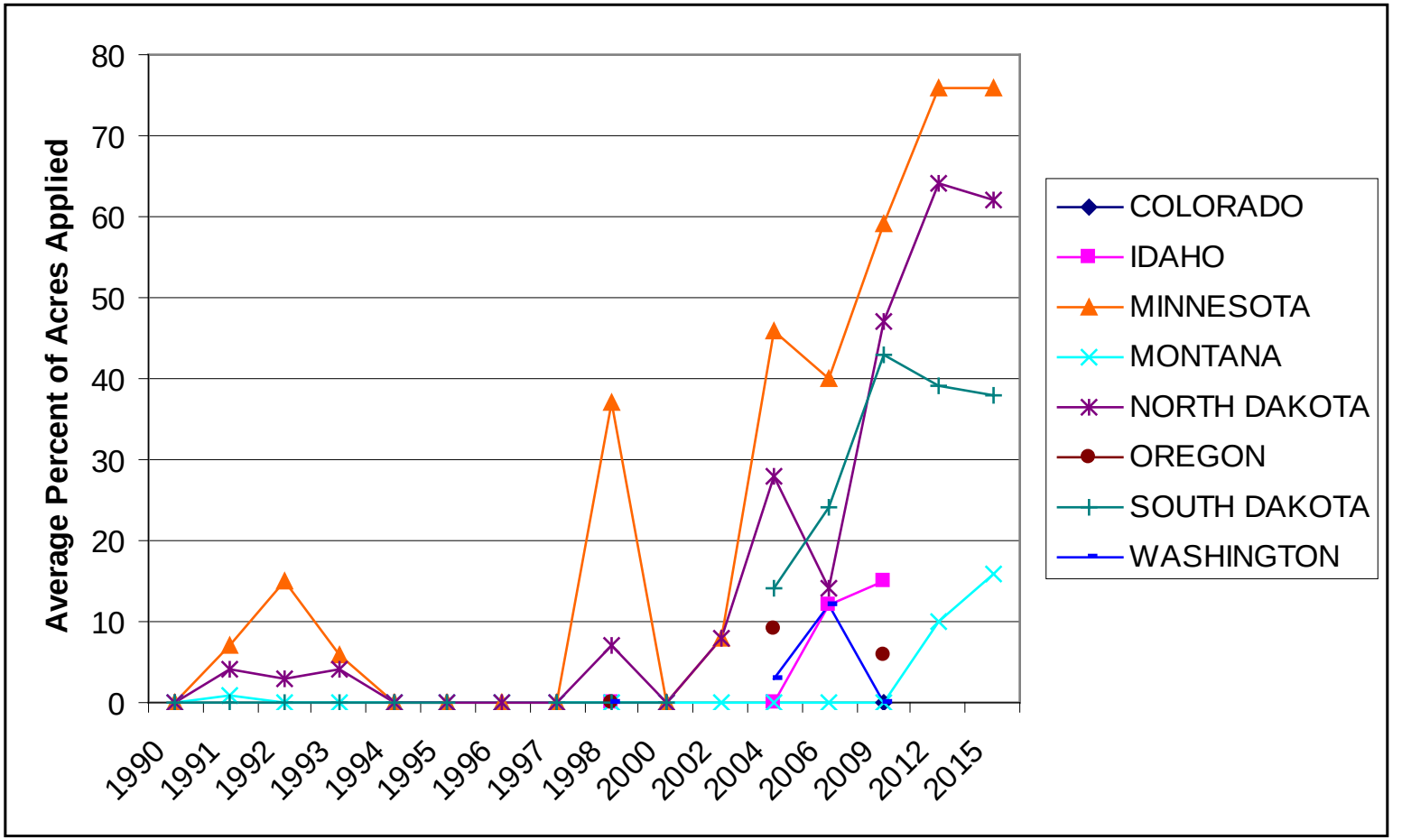



- 70% of area is M or MR varieties, up from 40% 2000
- Increasing (decreasing) share of M (MR)
- Revision in interpretation of MR and Moderate

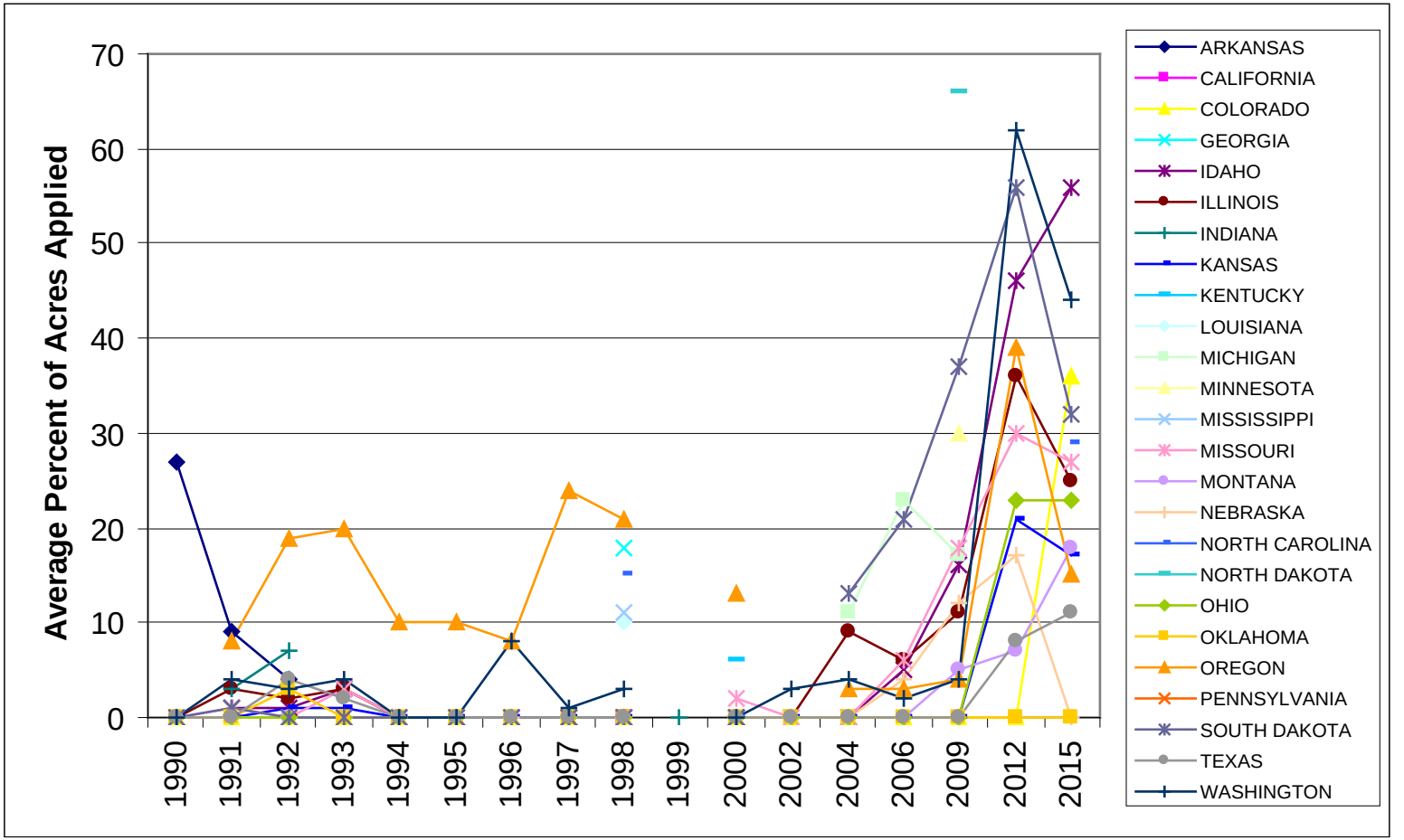
## Fungicide Use has Escalated in Importance

- Drastic increase in fungicide use following mid-2000s
- **It is clear:** fungicide use has important impact on reducing (aggregate) DON levels

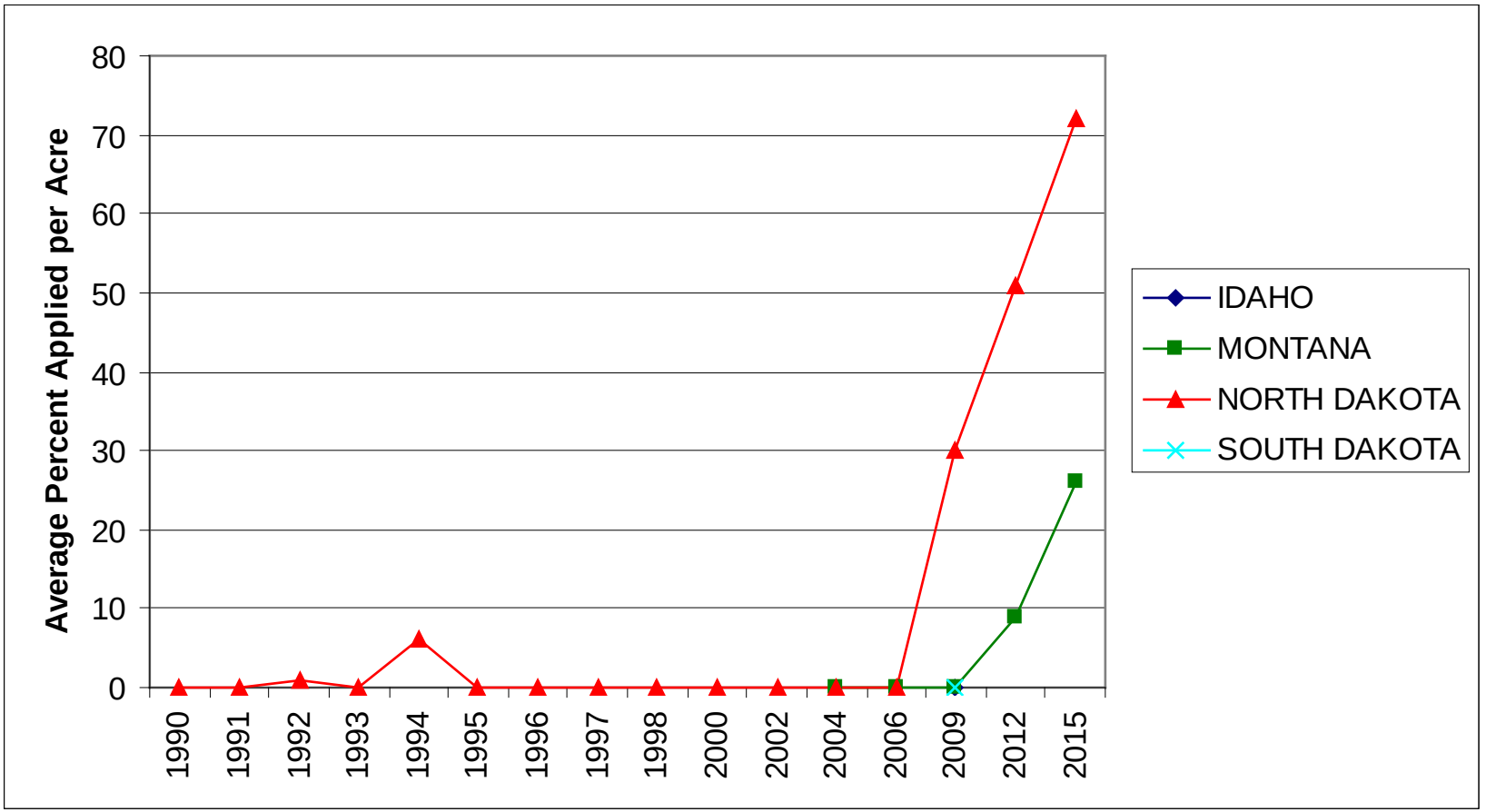
# HRS: Fungicide Use by State



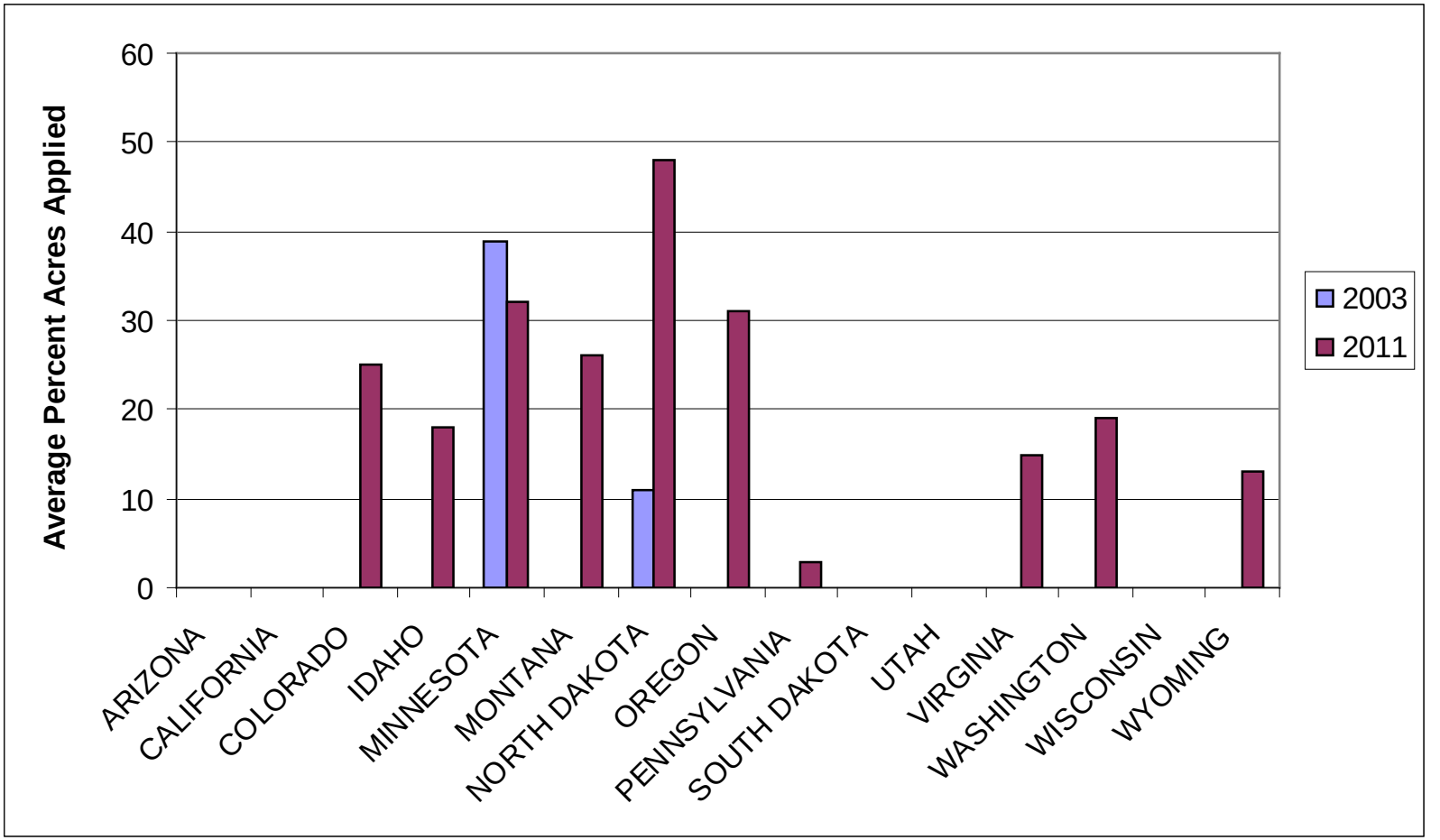
# Winter Wheat:  Fungicide Use by State



# Durum:  Fungicide Use by State



# Barley:  Fungicide Use by State



# Market mechanisms

- Regulations
- Specifications
- Discounts:  Futures and cash markets

# Market Specifications/Limits

- **Domestic Specifications:**
  - 2 ppm + s.t. discounts
  - .5 ppm Barley
- **Discounts for deviations**
- **Importers**
  - Stringent specifications (Max DON=2 for most)
  - Tight limits in some countries will restrict origins at which they can procure (Japan, EU, China, S. Korea)
- **CODEX--proposal**

| Country | DON Limit (ppm) | Country | DON Limit (ppm) |
|---|---|---|---|
| Bolivia | 2 | Israel* | 1 |
| Canada* | 2.0(under review) | Japan* | 1.1 |
| Brazil | 2 | Jamaica | 2 |
| Chile | 2 | Jordan | 2 |
| China* | 1 | Malaysia | 2 |
| Colombia | 1.25; | Mexico | 2 |
| | 2 in contracts | Nicaragua | 2 |
| Costa Rica | 2 | Norway* | 1 |
| DR | 2 | Nigeria | 2, as needed |
| Ecuador | 2 | Pakistan | 2 |
| Egypt* | 1.25; | Panama | 2 |
| | 2 in some contracts | Peru | 2 |
| El Salvador | 2 | Philippines | 2 |
| EU* | 1.25 common wheat; 1.75 durum | Russia* | 0.7 |
| | 1.75 Durum | Singapore | 2 |
| Guatemala | 2 | South Korea* | 1 |
| Haiti | 2 | Taiwan | 2 |
| Honduras | 2 | Thailand | 2 |
| Indonesia | 2 | Trinidad-Tobago | 2 |
| India* | 1 | Vietnam | 2 |
| Iraq | 2 | Venezuela | 2 |

*Government Regulation

Source: U.S. Wheat Associates.

## Market Discounts

- **Futures Markets**
  - Evolving from nil to now converging to commercial
- **Cash Markets**: Most common discounts

| Crop Year | Specification limit (allowed) without discounts | Discount |
|---|---|---|
| 2011 | 1 | 5c per ½ ppm; >5.1=60c |
| 2012 | 2 | 0-2.6 ppm=0; >2.6 10c |
| 2013 | 2 | 5c/ ½ ppm over 2; |
| 2014 | 2 | 10c/ ½ ppm |
| 2016 | 2 | 5c/ ½ ppm for 2.1 to 4 ppm; 10c/ ½ ppm >4.1 ppm |

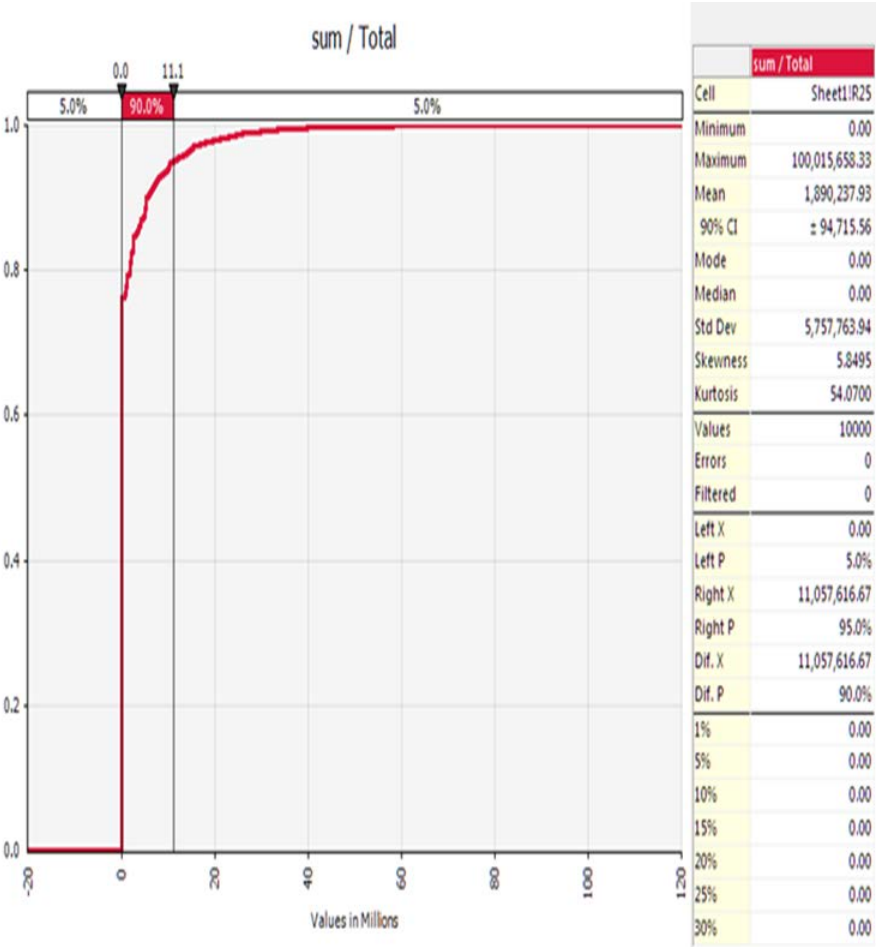
## General Observations

- Limited public information on these discounts over time.
- Discounts do not seem to have changed substantially but, vary by class.
- Discounts tend to be
  - Larger and more variable at the country elevator; or origin mills
  - Smaller at the level of intermediate traders and
  - Discounts at mills vary depending if it is an origin or destination mill

# Structure of Market Discounts

# Distribution of Discounts

- **Impacts of discounts depend on 2 random variables**
  - DON level
    - Varies through time and across regions
  - Discounts
    - Varies: time, geography, buyer
- **St. Sim. Result:**
  - **Value of DON discounts in HRS=$1.9 m/yr**
  - No discounts applied (about 75%) a large proportion of time
- **Impact of CODEX**: DON discounts in HRS=$4.6




| | sum / Total |
|---|---|
| Cell | Sheet1!R25 |
| Minimum | 0.00 |
| Maximum | 100,015,658.33 |
| Mean | 1,890,237.93 |
| 90% CI | ± 94,715.56 |
| Mode | 0.00 |
| Median | 0.00 |
| Std Dev | 5,757,763.94 |
| Skewness | 5.8495 |
| Kurtosis | 54.0700 |
| Values | 10000 |
| Errors | 0 |
| Filtered | 0 |
| Left X | 0.00 |
| Left P | 5.0% |
| Right X | 11,057,616.67 |
| Right P | 95.0% |
| Dif. X | 11,057,616.67 |
| Dif. P | 90.0% |
| 1% | 0.00 |
| 5% | 0.00 |
| 10% | 0.00 |
| 15% | 0.00 |
| 20% | 0.00 |
| 25% | 0.00 |
| 30% | 0.00 |

# Statistical Relations (G. McKee)

- Econometric models used to examine factors that impact wheat yields, and DON levels
- Data from field trials from
  - 2007-2010 for wheat
  - 2008-2015 for barley.
- Data on management techniques were from Cowger.

- **Models Specified:**
- Wheat yield=*f* (variety (resistance), disease pressure, fungicide, incidence, severity, DON, location, year, class)
- Wheat DON=*f* (fungicide, resistance (variety), incidence, fungicide, class, severity, location, year)
- Barley DON=*f* (variety (resistance), disease, fungicide, resistance, incidence, severity, location, year)

# Findings: Wheat quality

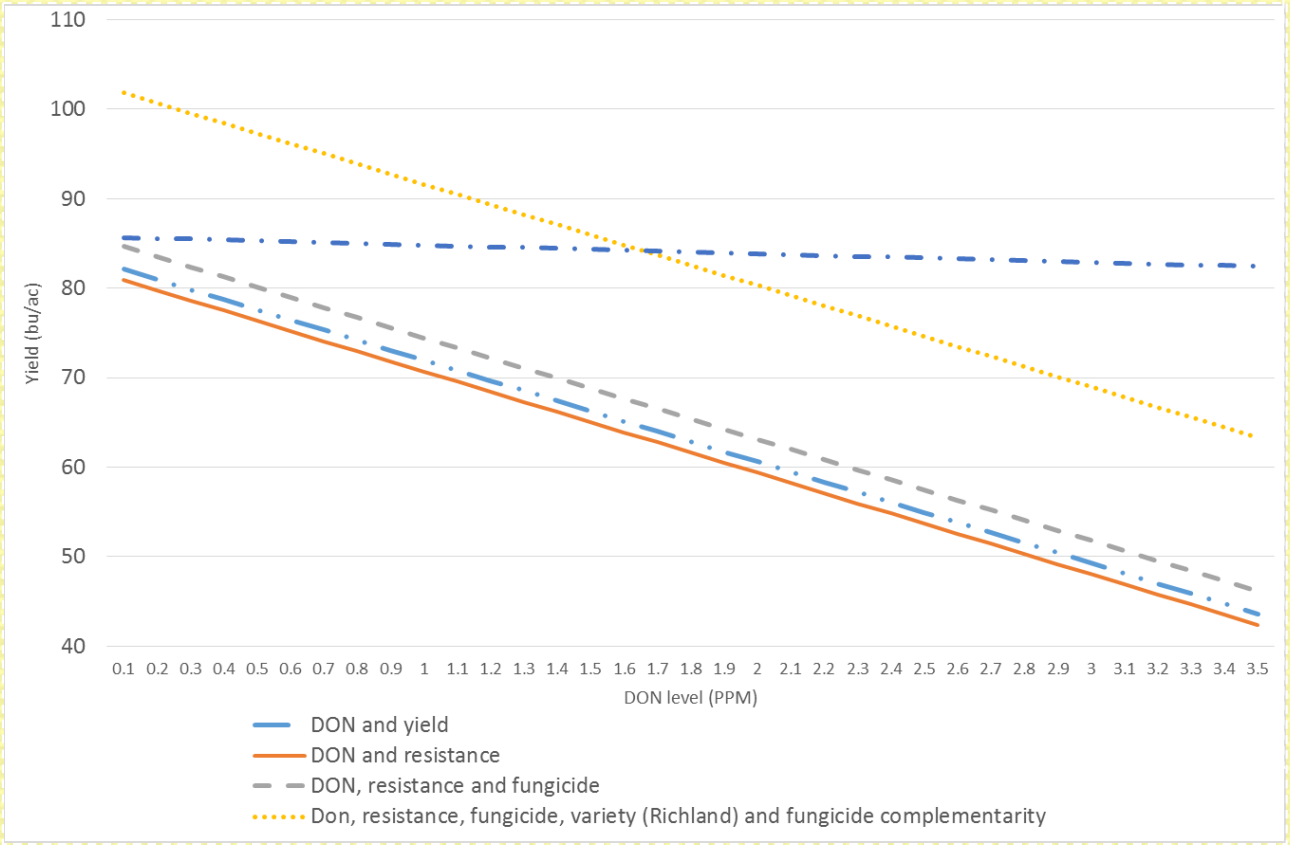
- **Statistical results:** good;
- **Significant effect of fungicide application**
  - Fungicide has significant, negative effect on DON
  - Impact is complementary with variety resistance
  - Greater marginal impact on HRS
- **Scab resistance in variety is significant**
  - Negative effect on DON by increasing scab resistance
- **Incidence (+), Severity (+) have significant effects**
  - Unique relationship based on disease pressure and class

# Summary (Highlights)of Results:

- **Fungicide is important for both wheat and barley.**
  - One of the most important variables impacting wheat yield, and DON in wheat and barley.
  - Fungicide had the impact of increasing yields in wheat, and lowering DON in wheat and barley.
  - Impact of fungicide dependent (complementary with) on the variety i.e., its impact is complementary and varies across varieties;
- Moderately resistant varieties increase wheat yield by about 5 b/a and lowers DON;

# Tradeoff: DON and Yield

## Wheat




- DON – significant negative effect on wheat yield
- Decrease DON from 1.0 to .5: increase yield ~ 7 b/ac.
- Magnitude impacted by fungicide use.

**Tradeoffs between wheat yield (bu/ac), DON (PPM), scab resistance, fungicide And the complementary effects of fungicide and variety (e.g. Richland).**

## Impacts of DON on Grower Returns, Risks and Value of Mitigation Strategies

- ***DON***: results in
  - greater risk
  - lower returns
- Growers adopt varying strategies that mitigate DON risks.
- Effect of these is to reduce risk and increase returns.

- ***Risk Premium:*** Market compensates growers for the increased risk in the form of higher prices.
- Commonly referred as a 'risk premium.'
- Observed in wheat and malting barley relative to alternative crops (e.g., corn, soybean, canola, etc.), which are less risky.

# Impacts of Fung. and MR Varieties on Risk and Return

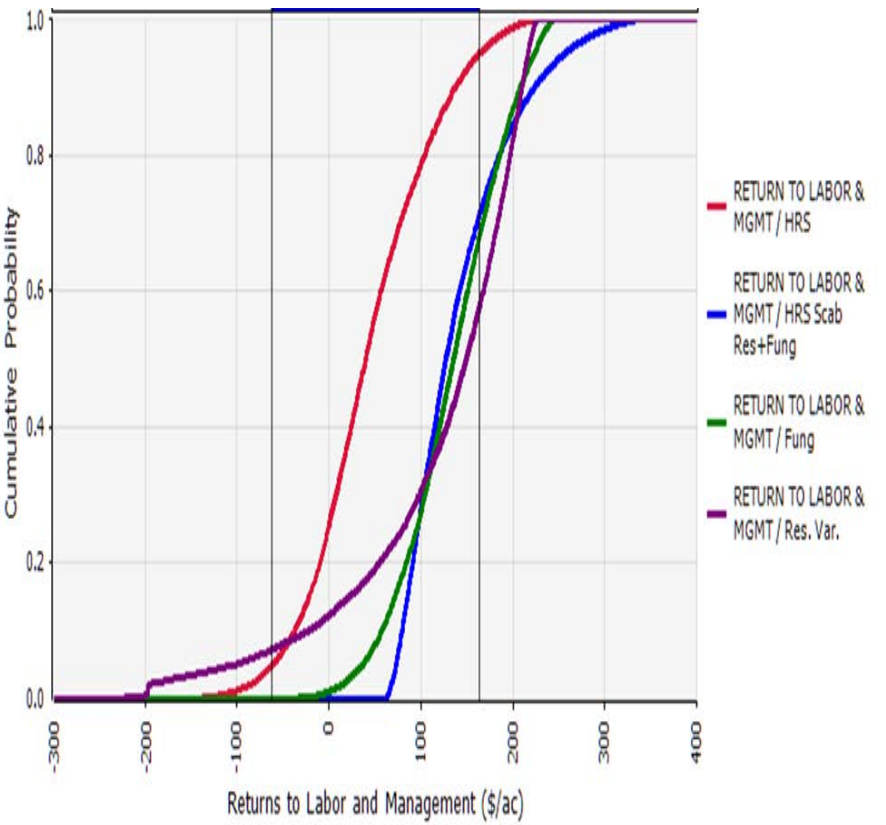
- **Fungicide and MR varieties:**
  - Reduces risk
  - Increases return

  relative to the alternative of not adopting the technology.
- Or, similarly, the impact of not having these technologies is to increase risk and lower returns.

| HRS | No Fungicide No Mod. Res. Varieties | Fungicide and Mod. Res. Varieties | Fungicide | Mod. Res. Varieties |
|---|---|---|---|---|
| Mean | 44.73 | 140.78 | 133.57 | 118.09 |
| Std. Dev. | 67.29 | 56.8 | 56.45 | 99.28 |
| | | | | |
| **SRW** | | | | |
| Mean | -135.15 | -62.68 | -87.2 | -84.45 |
| Std. Dev. | 67.95 | 80.37 | 80.87 | 81.08 |
| | | | | |
| **HRW** | | | | |
| Mean | 27.91 | 43.01 | 42.84 | 29.54 |
| Std. Dev. | 36.43 | 24.99 | 37.37 | 34.78 |
| | | | | |
| **Malting Barley** | | | | |
| Mean | 138.47 | 164.55 | 161.96 | 141.82 |
| Std. Dev. | 130.61 | 119.04 | 136.05 | 127.59 |

# Impacts of Fung and MR Varieties on Risk and Return

- **Risk Premiums**: amount by which growers need to be compensated to adopt a more risky alternative i.e., as if the technologies were not available.
- Alternatively: interpret as the value of these technologies to growers.
- **Results indicate that growers would need to be compensated:**
  - HRS $130/acre (in that year)
  - SRW $49/acre;
  - HRW $28
  - Malting Barley $29/acre
  - **HRS greater due to**
    - Greater returns/acre
    - Greater marginal impact of fungicide on yield
    - vs other wheat classes



# End-Use Survey: Wheat Flour Mills

- **90 percent of wheat mills impacted by DON. Classes of wheat affected across firms were**
  - 60% HRW,
  - 80% HRS,
  - 70% SRW, and
  - 30% HAD;
- **To respond to the incidence of DON, most firms**
  - Expand their draw areas (about 10% of their purchases)
  - Added cost ranged from 10-30c/b in a normal year; to 250-300c/b in an epidemic year.
- **Ranges for discounts varied from**
  - None, to a range of 5-300 c/bu.
- **Technology used for testing for DON: Neogen (largely)**

# End-Use Survey: Wheat Flour Mills

- **Average cost of testing: $13.66 and ranges from $6.00 to $25/test;**
- **Costs for segregating and blending: about 2c/bu to 10c/bu.;**
- **Firms indicated that the innovations most important for improvement in DON were**:
  - 1) Fungicide;
  - 2) Farm Management:
  - 3) Varieties;
  - 4) Crop rotation; and
  - 5) Milling practices
- **Other diseases indicated as potentially problematic included**,
  - UG99,
  - Black Tip,
  - Ergot,
  - Other Fusarium,
  - Rust and Smut.

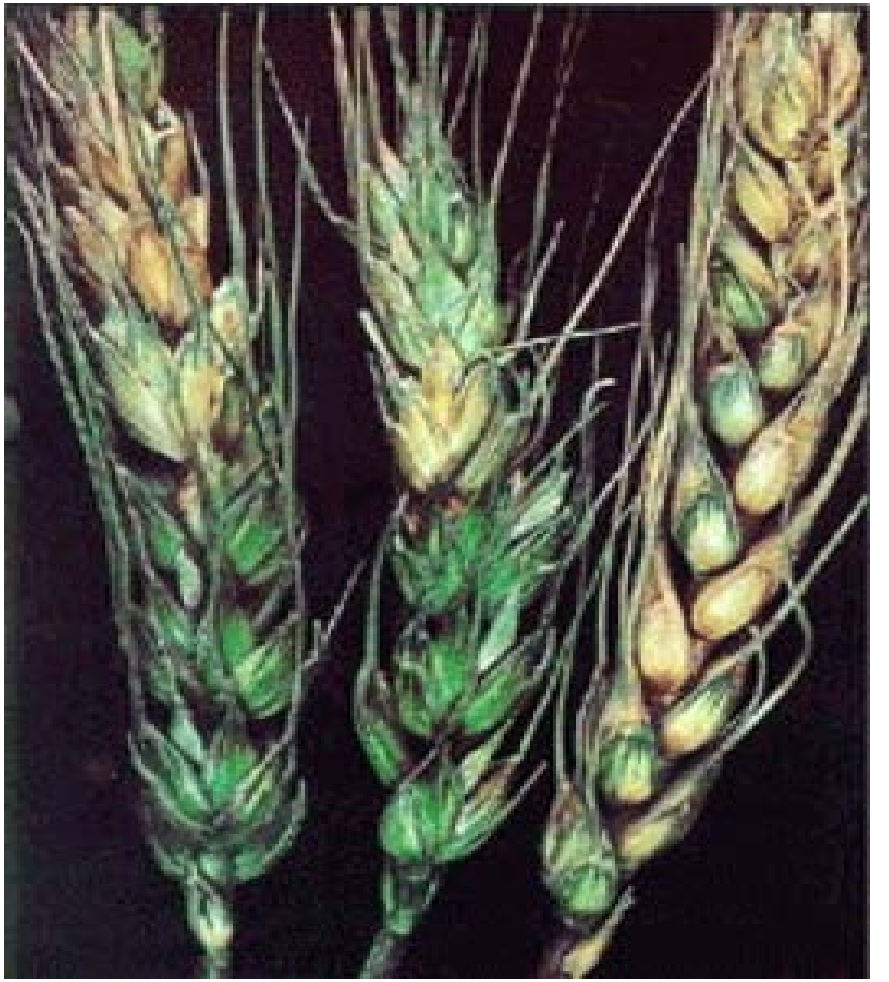
# End-Use Survey: Barley

- **DON Limits** on selling malting barley was most often quoted as
  - 0.4-0.5 ppm
- **In bad years**, firms expand target area
- **Firms ranked**
  - restrictions in contracts as most important in normal years,
  - pre-shipment testing more important in transition and epidemic years;
- **Discounts:** Most discounts of 10 to 50c /bu.

- **DON problematic:** firms indicated they would expand target areas
  - As high as 1000 miles
  - Half of firms indicated no expansion.
  - Added cost to bring in barley ranged from nil, to $1 to $2.5/bu.
- **Testing technology** Neogen
  - Also, Ez-Tox, Gas Chromatograph, and Environlogic
- **Cost of testing: $19.86/test**
- Testing intensity ranged from every shipment to 20% of shipments;
- **Factors most important in reducing DON:**
  - 1) Farm management practices;
  - 2) Fungicide;
  - 3) Crop rotations;
  - 4) Varieties; and
  - 5) Malting processing practices.

# Value of Production Loss (Dr. W. Nganje)

- **Production loss estimates (1000 Bu)**
  - Durum, Barley, Hard Wheats, Soft Wheats
- **Value of production loss**
  - Durum, Barley, Hard Wheats, Soft Wheats
- **Savings Due to USWBSI**
  - Durum, Barley, Hard Wheats, Soft Wheats
- **Return on Investment**
  - Net present value (NPV)
  - Internal rate of return (IRR)
  - Modified internal rate of return (MIRR)
  - Aggregate rate of return (AROI)



# Estimating Loss due to FHB

- Method: same as Nganje et al. (2004).
  - Regional Economic Impacts of Fusarium Head Blight in Wheat and Barley, *Review of Agricultural economics* Vol. 26, No. 3.
  - Expanded number of states (see scope) and years (1993-2014)
- Yields losses $\Delta Y = Y_{actual} - Y_{forecast}$
  - Estimated for each Crop Reporting District (CRD) in Various states
  - Regression based on: precipitation, temperature, trend (technology (e.g., introduction of new moderate resistant varieties), management practices, etc.).
- $\Delta Y$ shortfall adjusted (based on scab severity) to account for other factors that could affect yields (e.g., other diseases).
- Estimates adjusted to account for abandoned acres.

- **Total yield shortfall ("Production loss")** for CRD (per acre): multiplied by total production for that CRD (in bushels).

## Estimated Savings due to USWBSI: *Model Logic*

- **Value of Production loss:** derived **as Price *X* "Production Loss".**

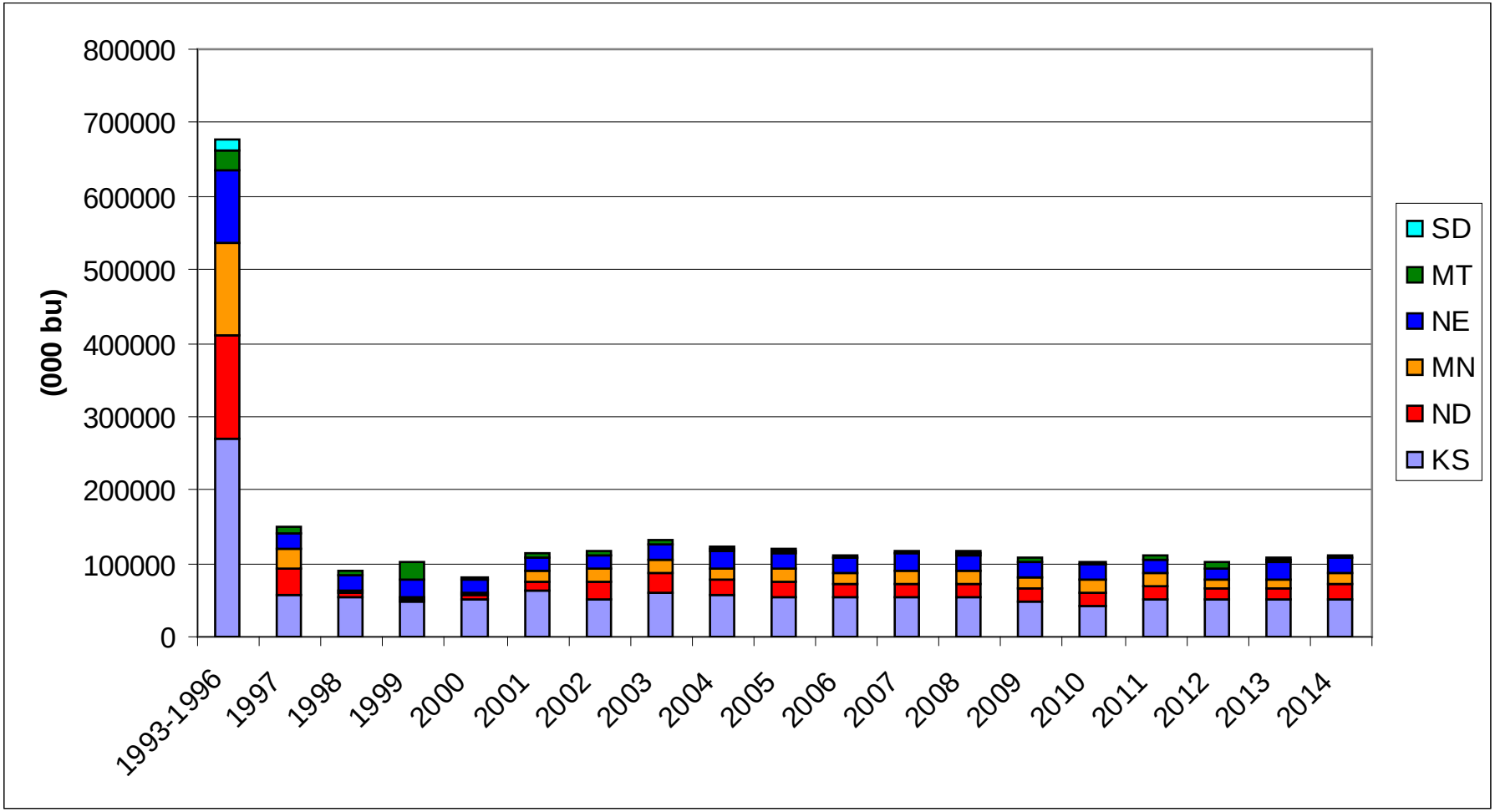
- Average value of production loss 1993 to 1996 (prior to the initiative) is from the base period.

- Difference from each subsequent year after USWBSI (1997 to 2014) is derived from the base period.

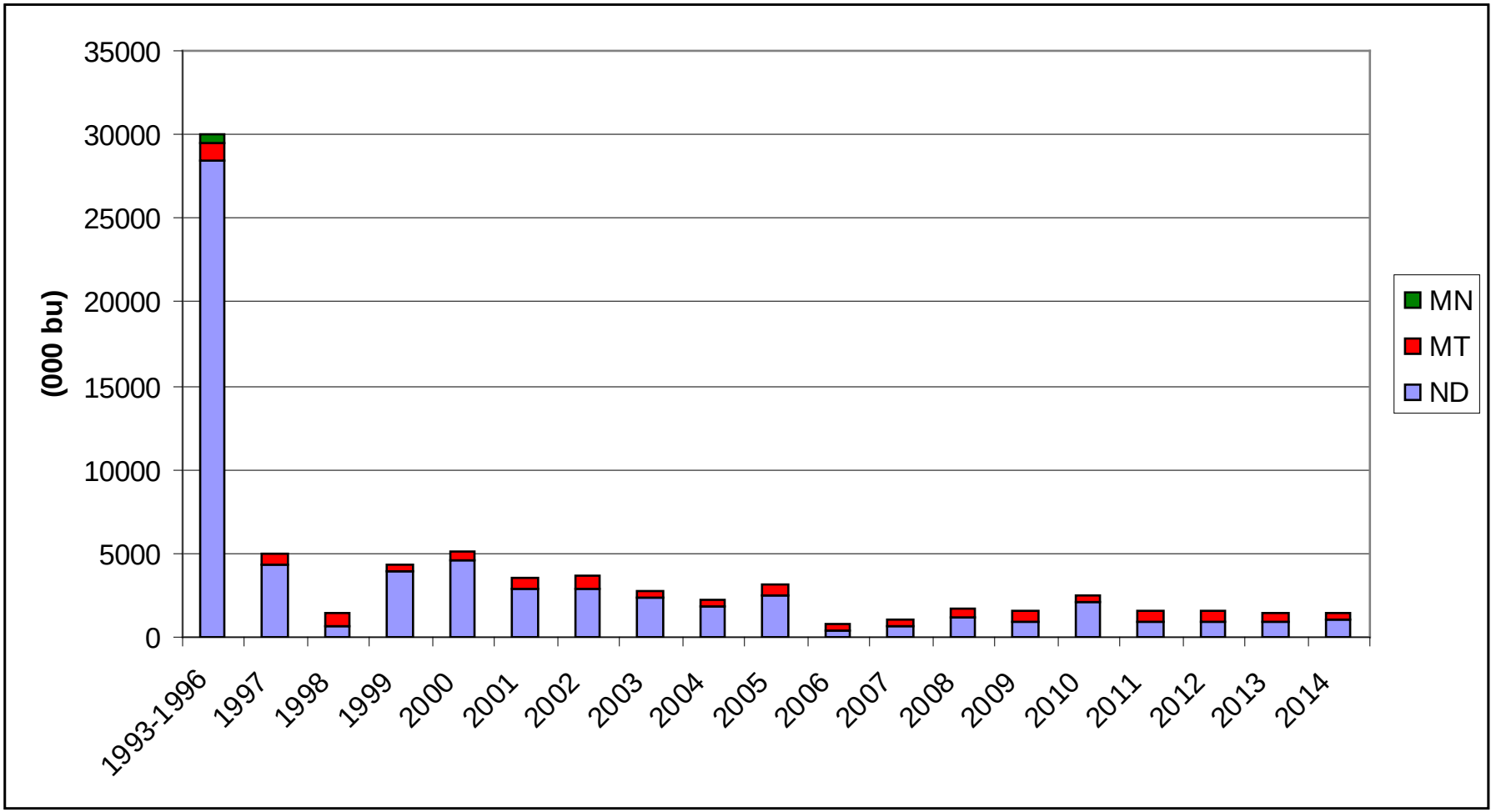
- Negative differences imply "savings" accrued as a result of the USWBSI.

# Production Loss Wheat and Barley by Class

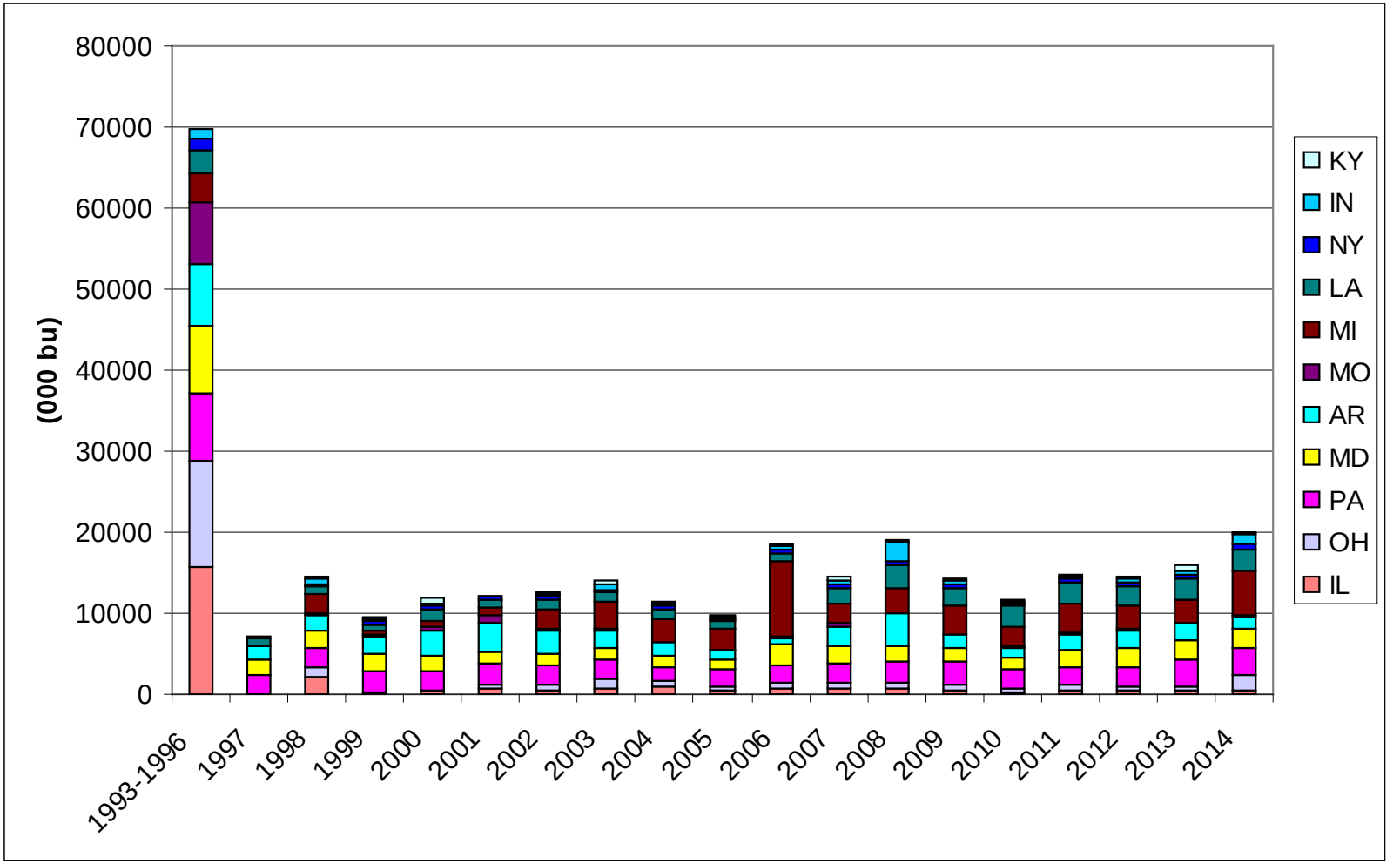
# Hard Wheats Production Loss (base period 1993-1996 pre-SCABI)



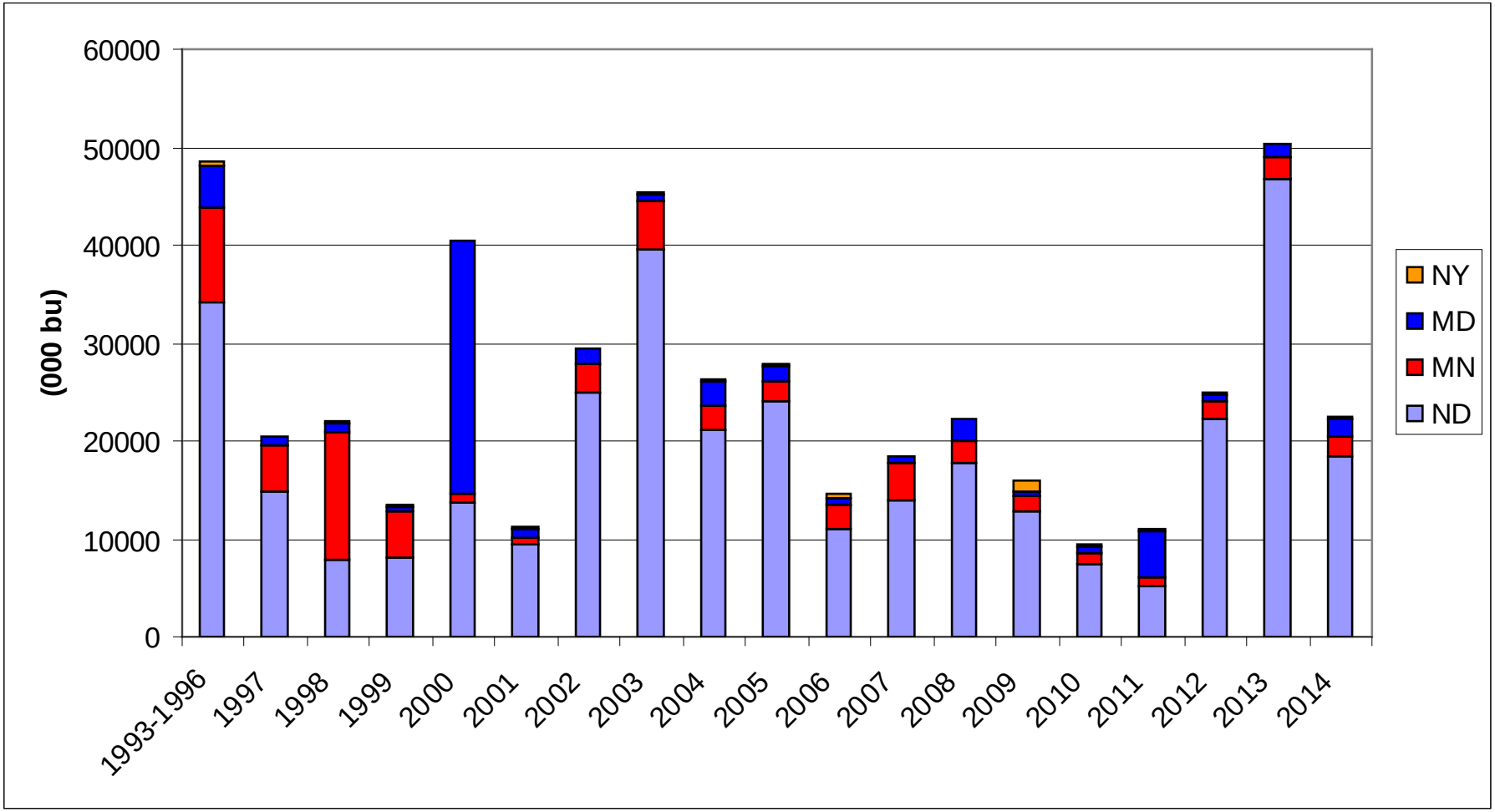
# Durum Production Loss



# Soft Wheats Production Loss



# Barley Production Loss



# Quantity of lost production varies by year.

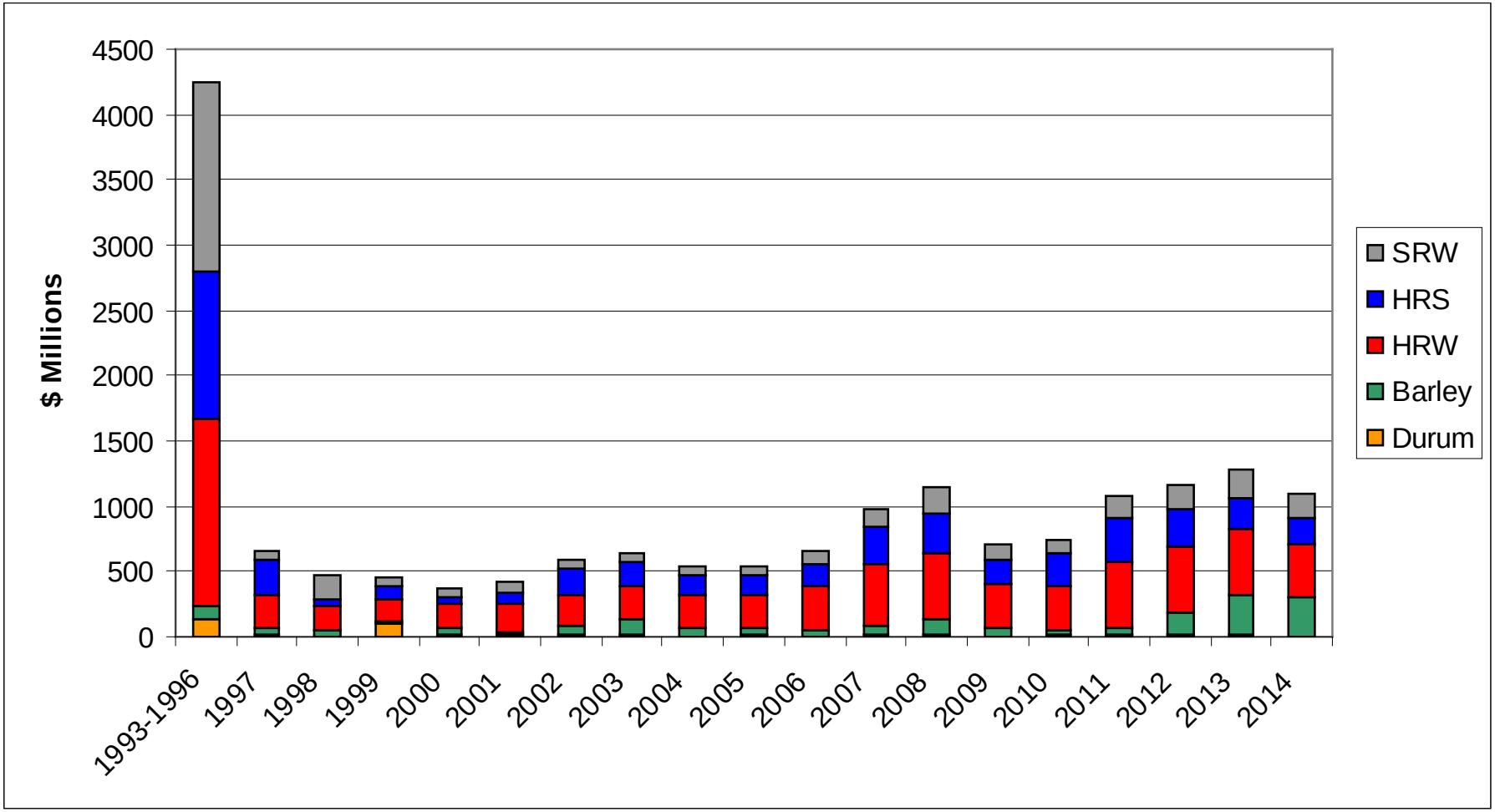
- **In 2014, this was:**

| | |
|---|---|
| HRS | 41 mb |
| Durum | 1.5 mb |
| HRW | 71 mb |
| SRW | 107 mb |
| Barley | 72 mb |

- HRS production was 7% less than would have been the case without SCAB

# Value of Production Loss Wheat and Barley by Class

# Value of Production Loss Wheat and Barley by Class

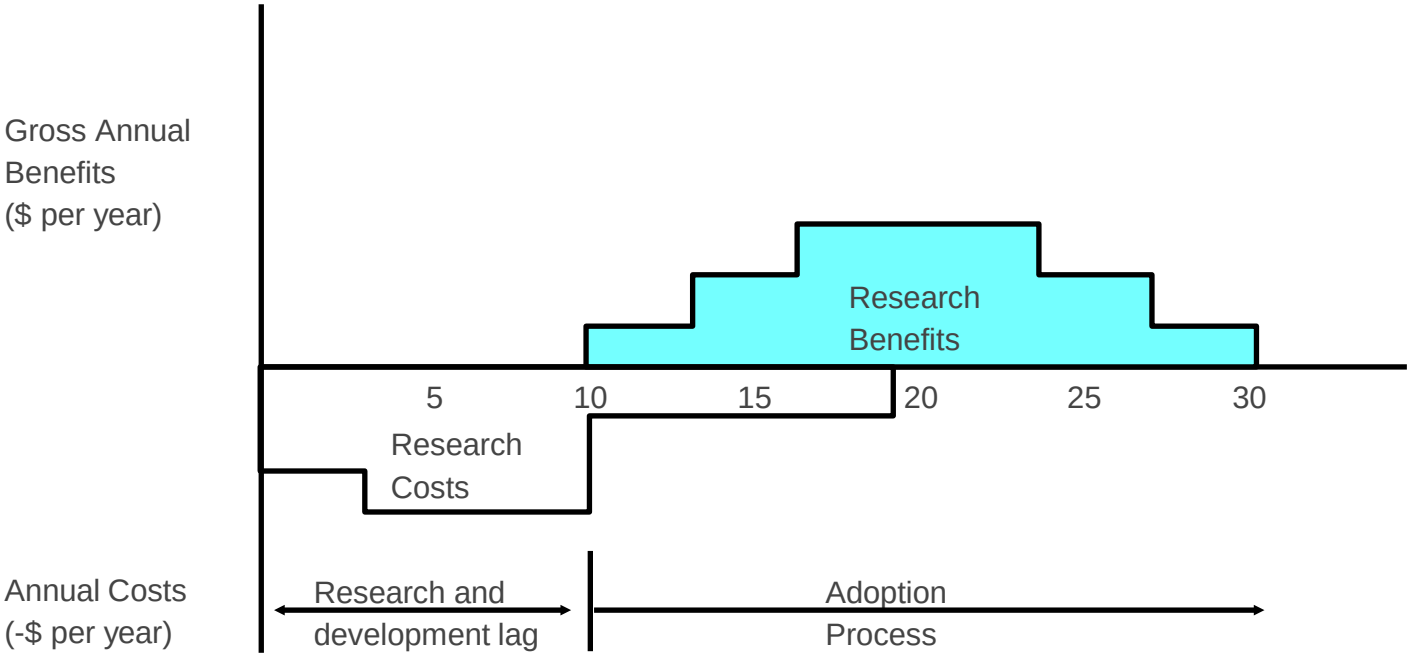


## Savings Attributed to USWBI

- Savings (value of reduced production loss):
  - Max in 1999 at $760 million
  - Average: $492 million/year
- Direct funding of research by USWBSI:
  - $4-5 million/yr
  - Total: $76 million
- Net savings: positive for all years 1997 to current.
- NPV is $5.4 billion

| Year | Savings (All Grains) | Funds Provided by USWBSI | Net Savings |
|---|---|---|---|
| 1993 | ($169) | $0 | ($169) |
| 1994 | ($60) | $0 | ($60) |
| 1995 | ($711) | $0 | ($711) |
| 1996 | ($220) | $0 | ($220) |
| 1997 | $445 | ($0) | $445 |
| 1998 | $635 | ($0) | $636 |
| 1999 | $760 | ($3) | $763 |
| 2000 | $759 | ($4) | $763 |
| 2001 | $675 | ($5) | $680 |
| 2002 | $554 | ($5) | $559 |
| 2003 | $532 | ($5) | $537 |
| 2004 | $585 | ($5) | $590 |
| 2005 | $581 | ($5) | $586 |
| 2006 | $475 | ($5) | $480 |
| 2007 | $314 | ($5) | $319 |
| 2008 | $297 | ($5) | $302 |
| 2009 | $447 | ($5) | $452 |
| 2010 | $388 | ($5) | $393 |
| 2011 | $312 | ($5) | $317 |
| 2012 | $345 | ($4) | $349 |
| 2013 | $372 | ($5) | $376 |
| 2014 | $387 | ($5) | $392 |
| Mean | $492 | ($4) | $497 |
| NPV | | | $5,368 |

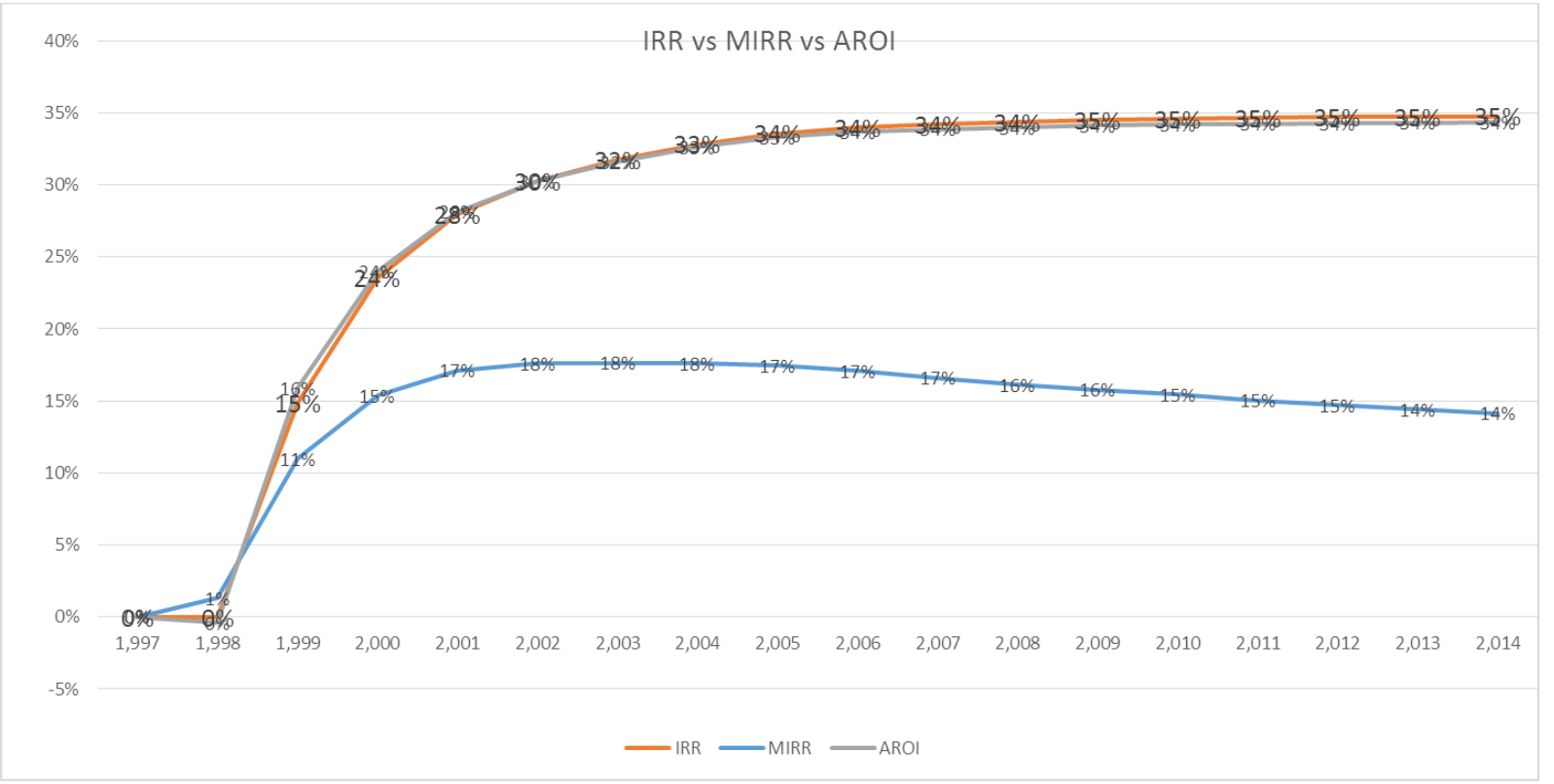
# Flows of Research and Development Benefits and Costs Over Time




Source: Alston et al. 2000.

# Returns on Investment: IRR, MIRR, AROI

- Returns Positive for each measure: ≈34% IRR
  - Comparable to returns to other ag technology (germplasm)



## Evolution:

- DON has improved but persists and imposes costs and risks on the industry
- **DON Mitigation has been effective:**
  - Fungicide is very important, and is complementary to MR varieties
  - Breeding has improved SCAB resistance
  - Other breeding technologies are being developed

## Industry responses to incidence of DON

- **Producers:**
  - Reduce production (shift to other crops)
  - Increase cost and risk
  - Increase fungicide!
  - Adopt MR varieties
- **Intermediate processors**
  - Pay risk premiums to induce DON mitigation
  - Impacts vary across mills (spatial) and through time (heterogeneous impacts on mills)
    - Impose specification limits
    - Expand draw area
    - Increase testing
    - Segregate and blend

# Summary

# Summary Of Annual Costs Accrued by Wheat and Barley Industries Due to DON (2015/16)

- **Numerous costs are accrued**
- **Most important costs**
  - Value of yield forgone
  - Risk premium paid to induce adoption of DON reducing technologies.
- **Followed by**
  - Fungicide
  - Added shipping costs
  - Testing and
  - Segregation
  - Discounts;

| | Wheat Total | Malting Barley | Total |
|---|---|---|---|
| | Million $ | | |
| **Value of Yield forgone** | 1,176 | 293 | 1,469 |
| **Costs accrued by Growers (Market)** | | | |
| Fungicide | 197 | 14 | 211 |
| Risk premium implied | 2,744 | 81 | 2,825 |
| Discounts to growers | 24 | | 24 |
| | | | |
| **Testing costs by Elevators** | 21 | 2 | 24 |
| | | | |
| **Testing costs and discounts for trading firms** | | | |
| Testing costs Traders (exporters--inbound) | 0.78 | | 0.78 |
| Testing at export loading | 4.53 | 0.08 | 4.61 |
| Discounts | | | |
| | | | |
| **Added Costs Accrued at Flour Mills and Malt F** | | | |
| Discounts | 8 | 1 | 9 |
| Testing | 11 | 4 | 15 |
| Segregation | 5 | 11 | 16 |
| Added trucking costs | 15 | 10 | 25 |

# Summary: Value of Reduced Yields Due to DON

- SCAB Initiative
  - Savings: **$497 million/yr for wheat and barley**
  - SCAB Initiative cost: **$4.23 million/yr.**
- NPV of investment: **$5.4 billion 1997- 2014**
- Return on investment to SCAB Research is substantial: **34%/yr (IRR)**

- Secondary impact analysis (on going)

## Incidence, Problem and Costs

- Problems persist Implications of adding cost and risk to the supply chain.
- Direct costs are related to use of fungicide, testing and increased draw areas.
  - Reliance on fungicide is notable, it is risky.
- **Industry accrues indirect costs**
  - Implicit risk premiums to induce planting and use of DON reducing technologies.
  - Without these technologies: cost to the industry would increase substantially.
- **Reducing SCAB ultimately reduces the costs accrued by the industry**

## Indirect Costs

- **Market mechanisms play important role in resolving problems related to excessive DON.**
  - The market works (though painfully)
    - Discounts, specification limits, testing, blending and segregation and targeting shipment
    - Vary across end-users (non-neutral impact)
  - Though DON has improved, use of market mechanisms persists in part due to inter—temporal (inter-year) marketing of cereals with DON.

# Implications: Wheat and Barley Industries

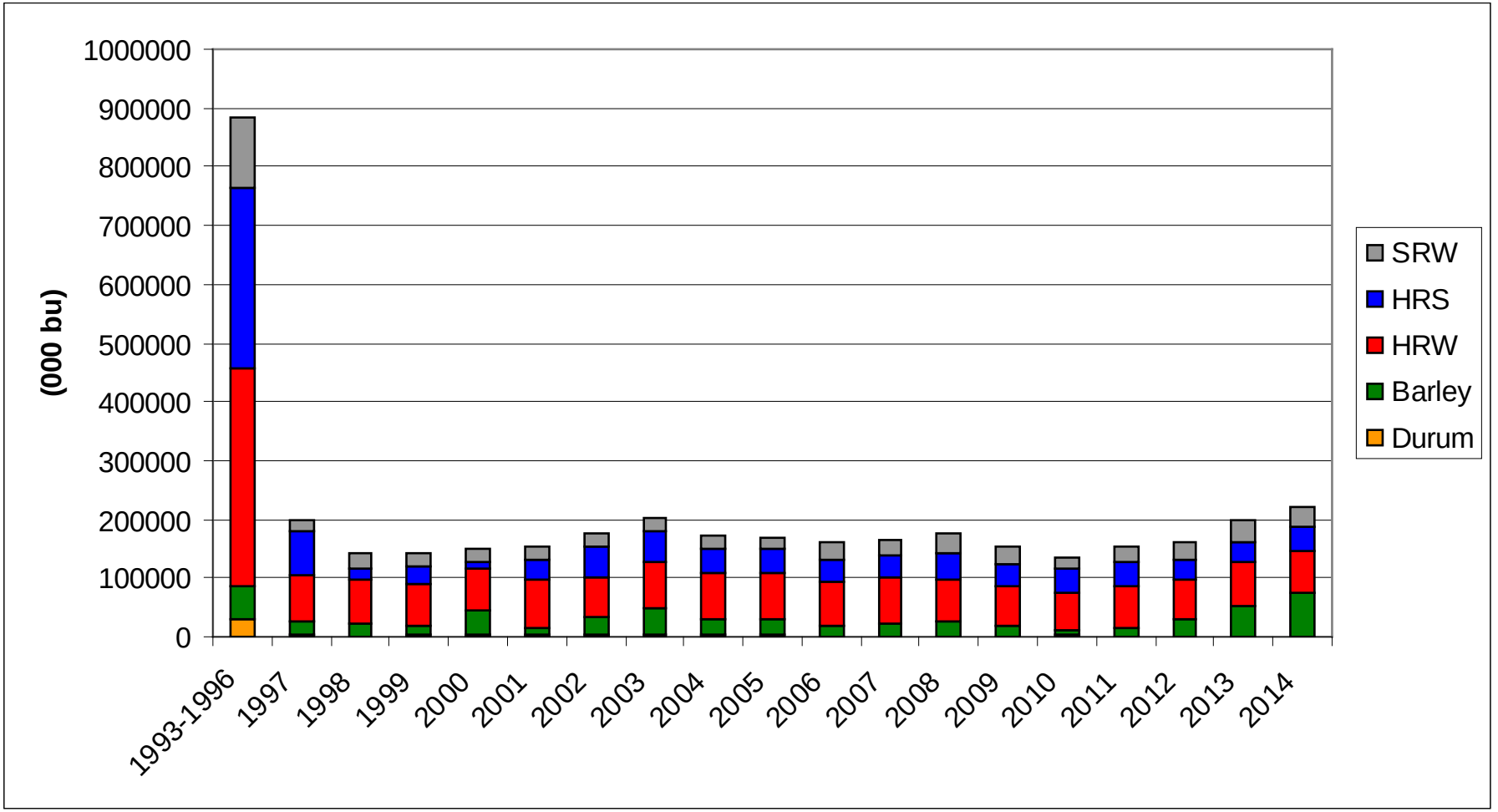
- **DON has devastating impacts on producers and the supply chain**
  - Substantial costs and increases risks.
- DON has improved; not been eliminated and remains a problem both temporally and spatially sporadic.
- Risk mitigation tools all reduce the impacts of DON. Two are particular important.
  - Fungicide use. This is substantial, at a high cost, but, is effective though risky.
  - Development and adoption of resistant varieties.
  - Fungicide and resistant varieties, are complementary and have an interdependent impact on reducing DON.
- **Perceptions of both traders and processors recognize these same conclusions**. Esp. Fungicide
- Other breeding technologies are emerging which may reduce DON.

- **Return on investment to research expenditures of the SCAB initiative.**
  - USWBSI:
    - Cost was $76 million since its inception
    - Generated $5.4 billion in net savings.
  - ROI: 34%
    - for expenditures on the SCAB initiative (ignoring in-kind costs)
  - Returns have reduced impacts of the disease.
  - **Very positive story!**
- **Further challenges/Opportunities**:
- **Outreach Demands:** Gower education ref. adopting MR varieties, fungicide, crop rotations, etc. including research support for these programs

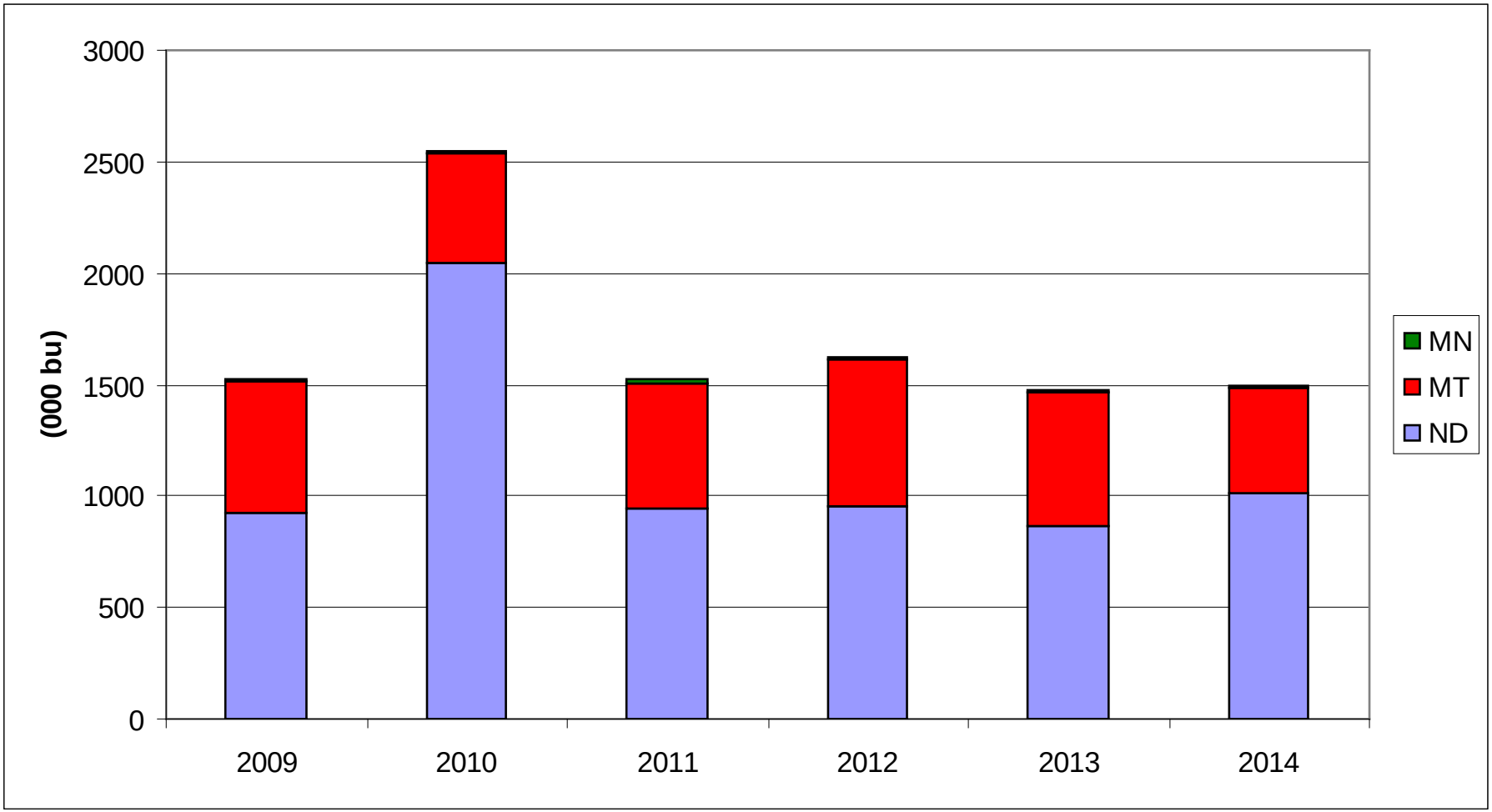
# Implications: *Scab Initiative*

# Appendix

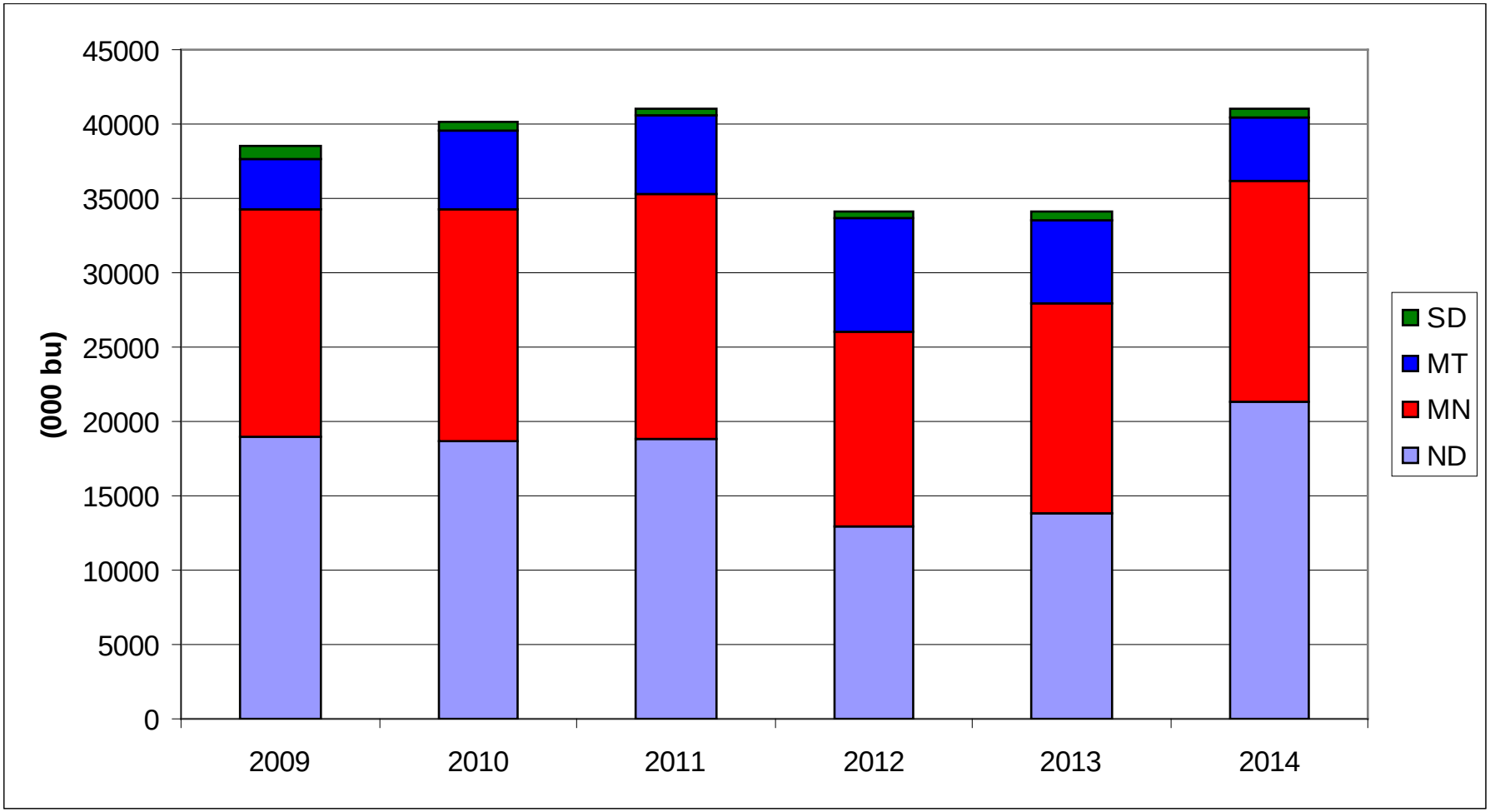
# Production Loss Wheat and Barley by Class



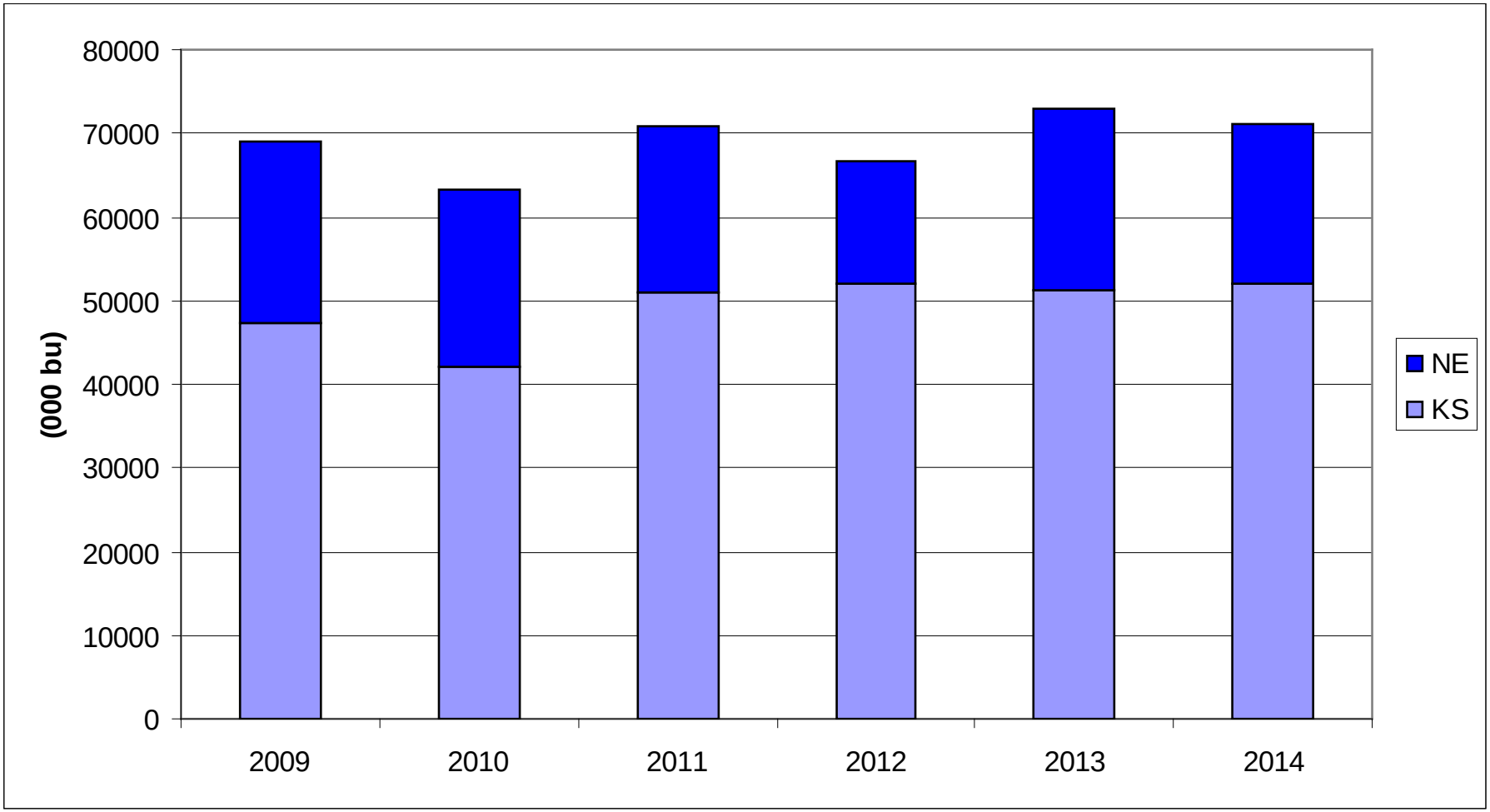
# Durum Production Loss



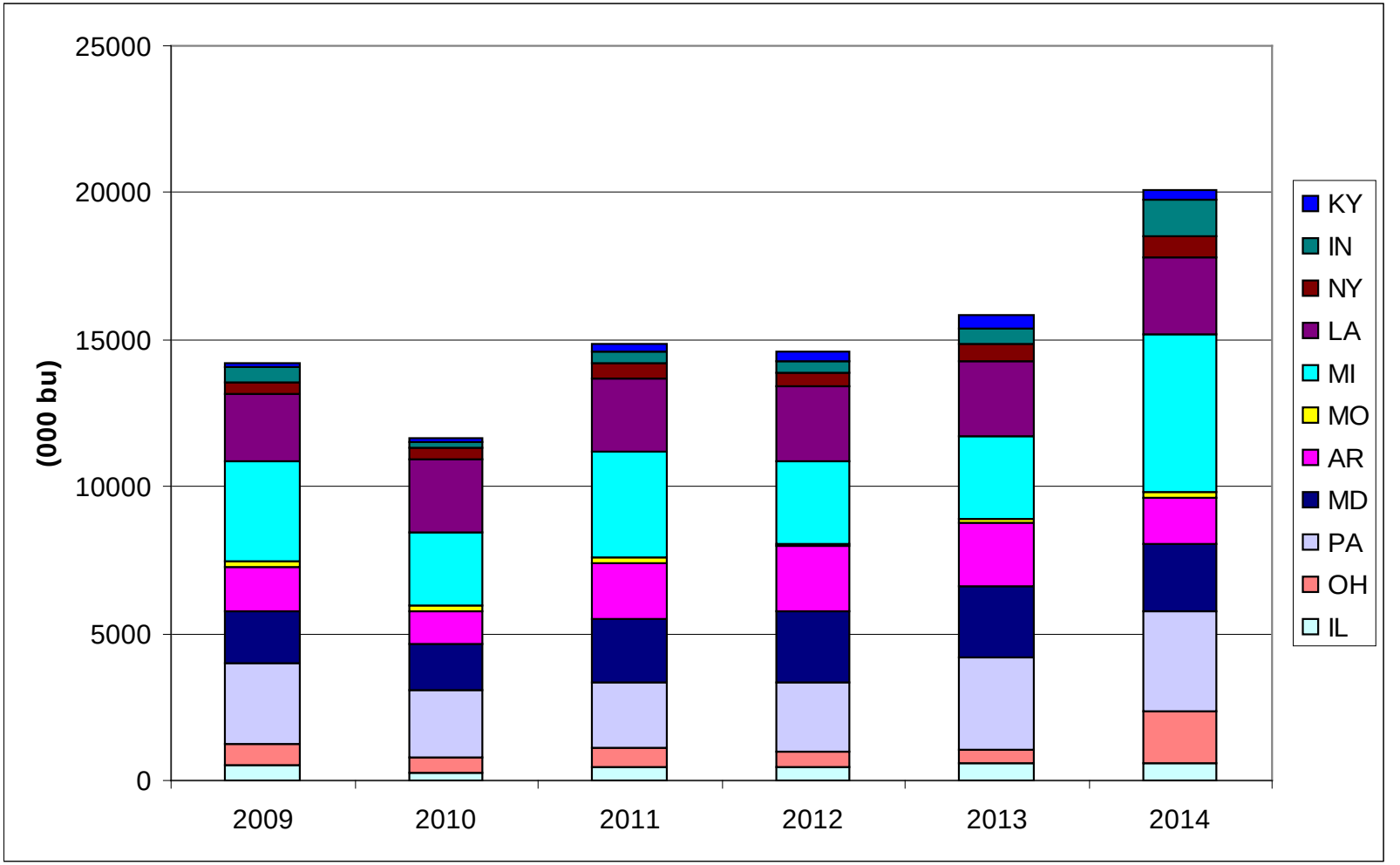
# HRS: Production Loss



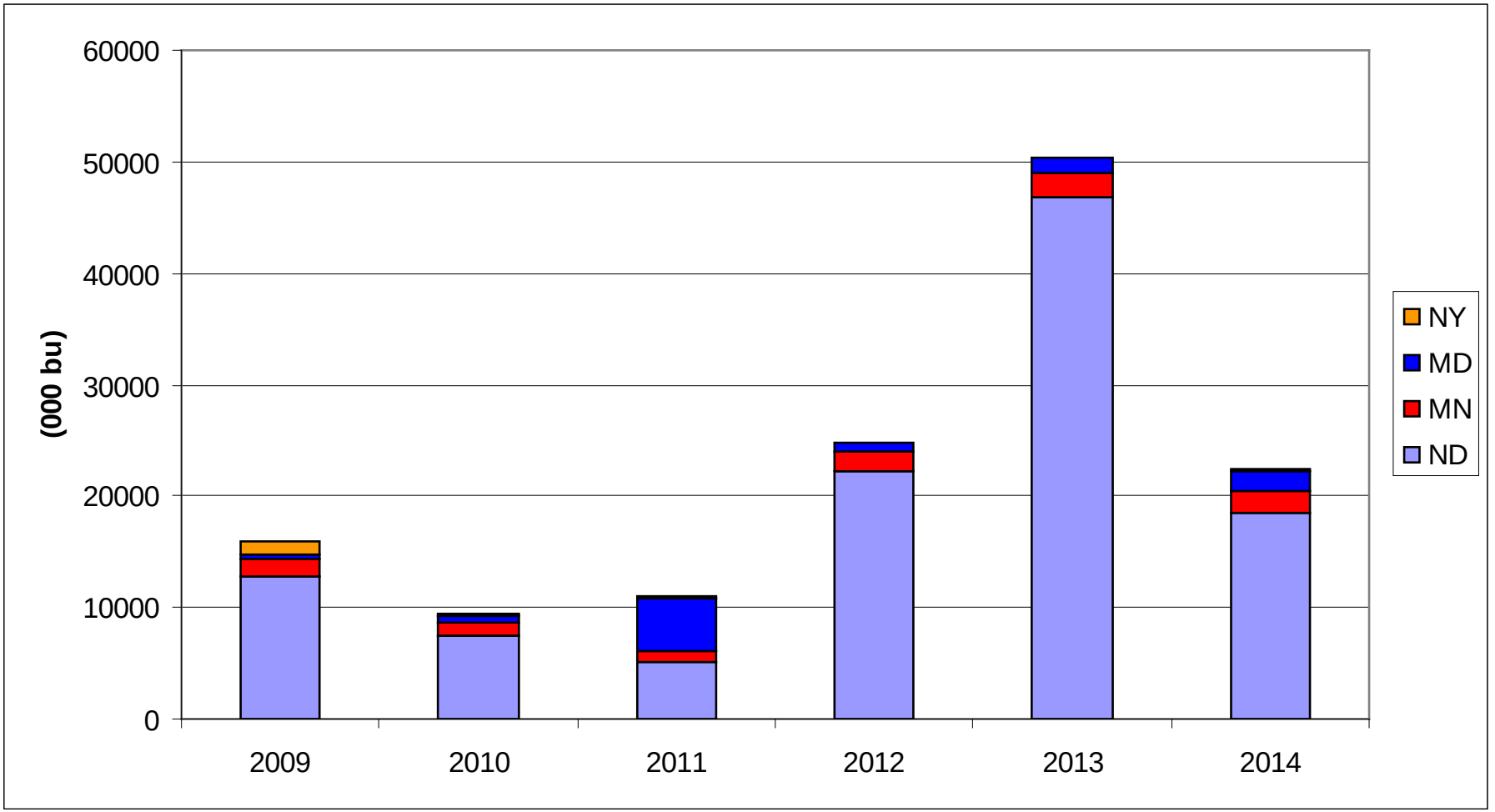
# HRW: Production Loss



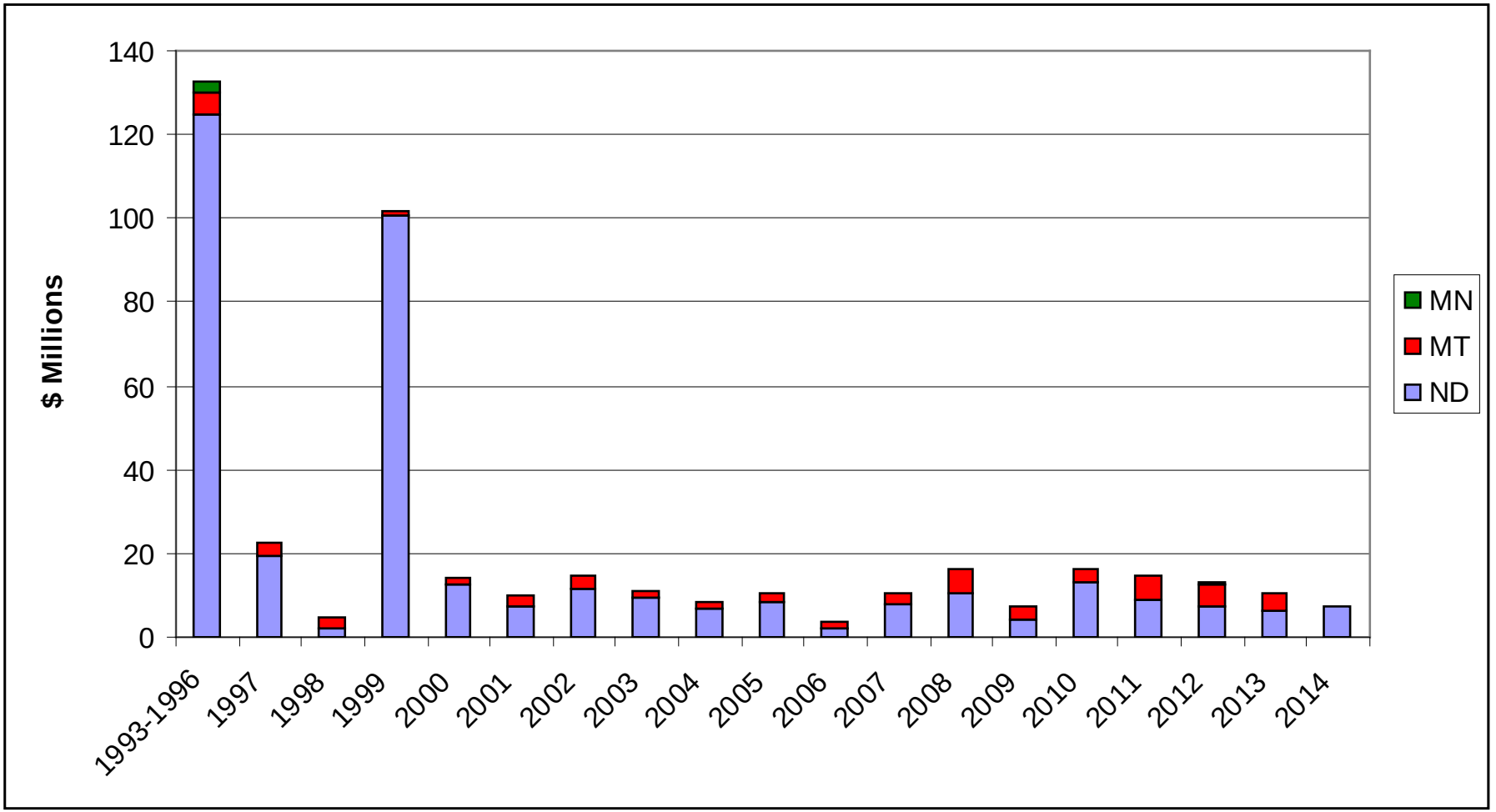
# Soft Wheats Production Loss



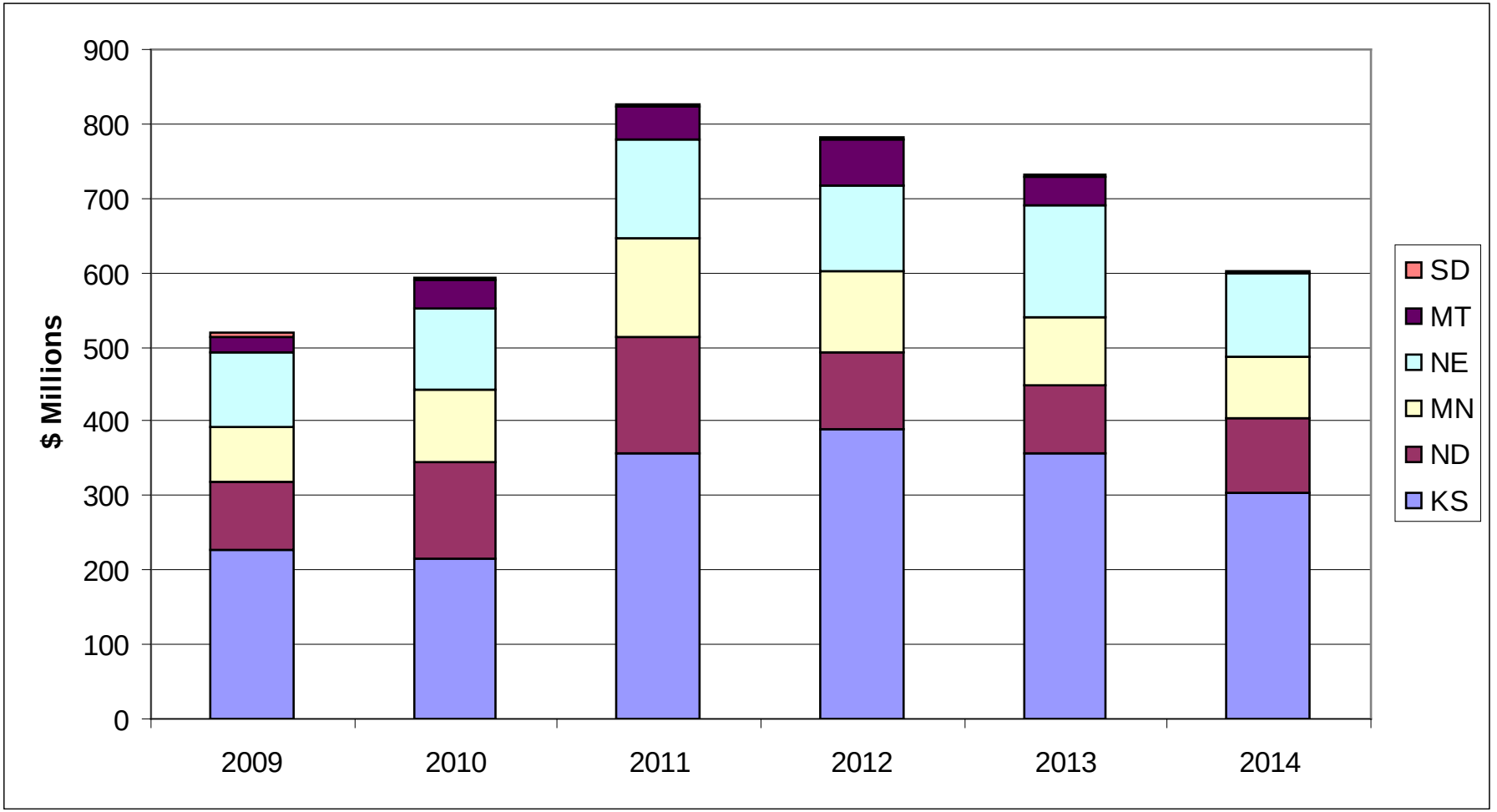
# Barley Production Loss



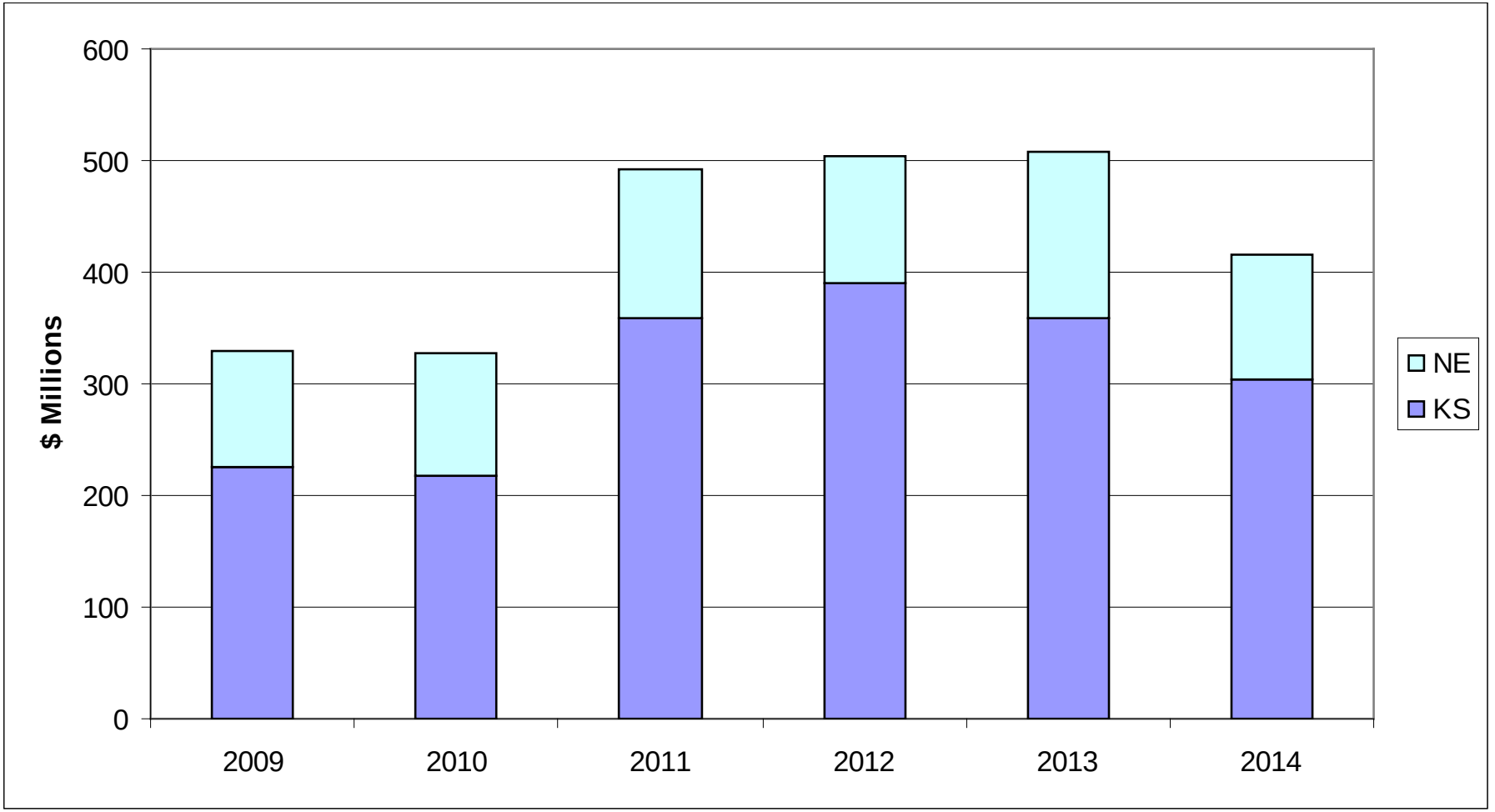
# Value of Durum Production Loss



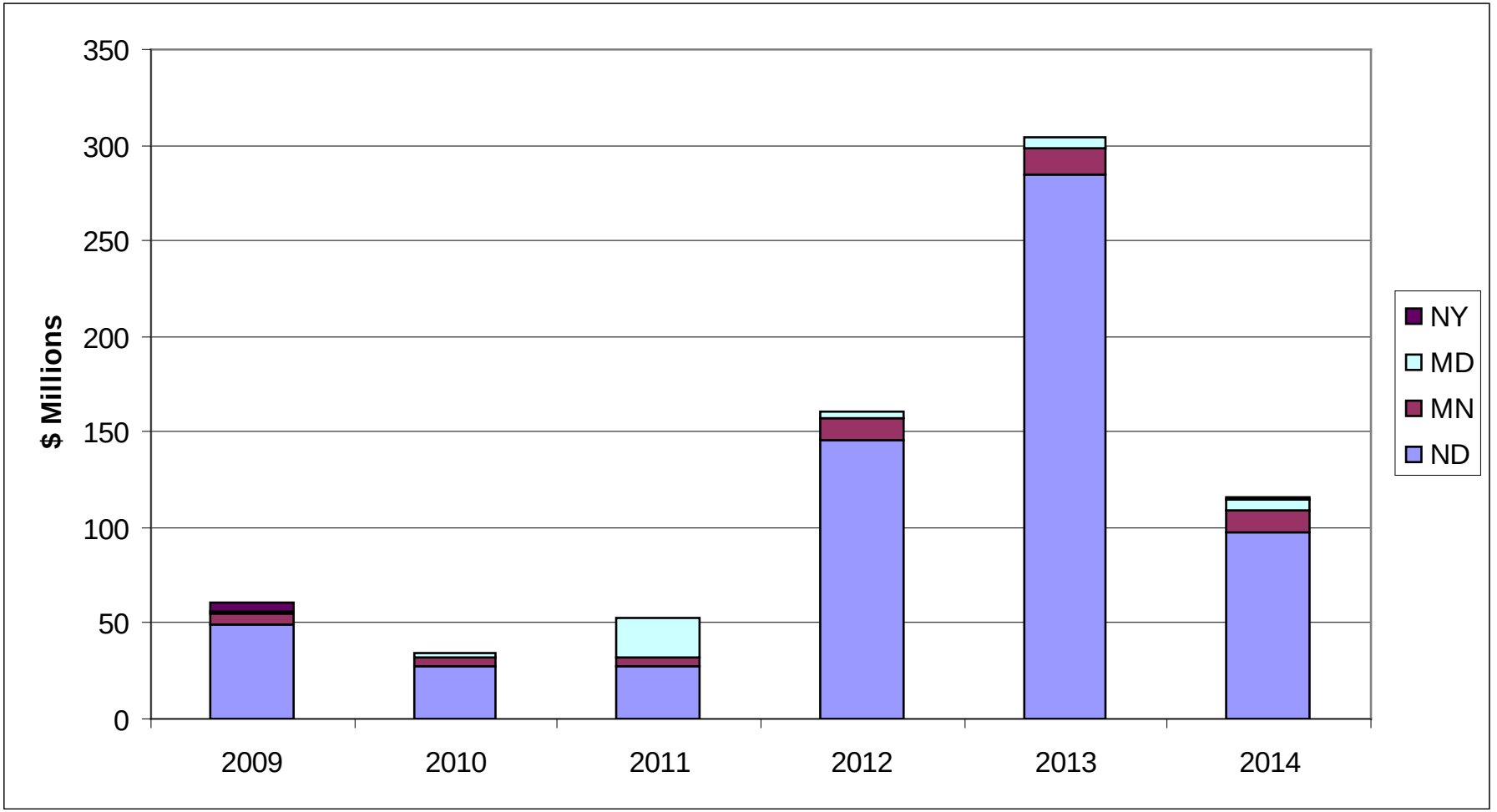
# Value of Hard Wheats Production Loss



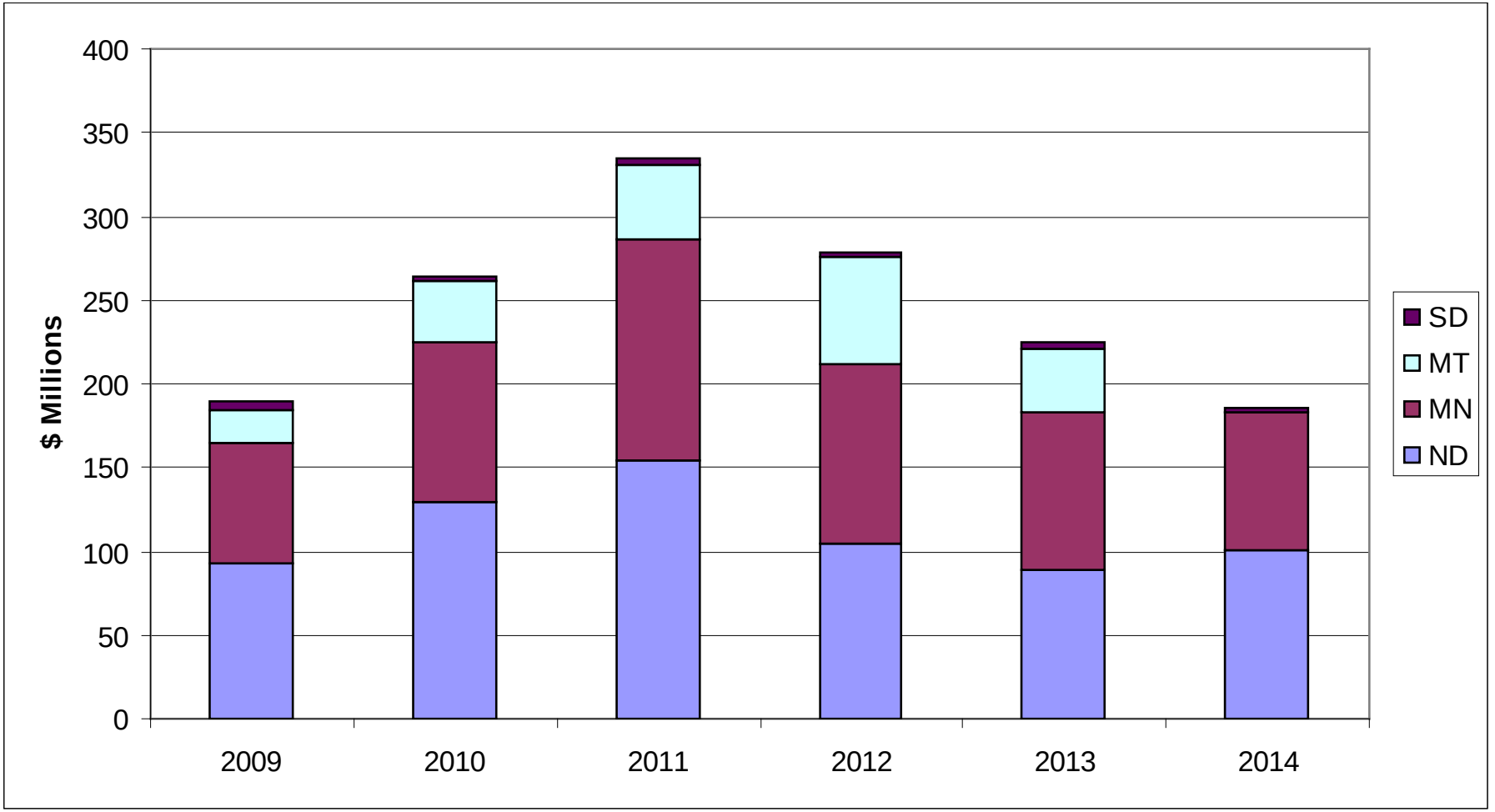
# HRW:  Value Production Loss



# Value of Barley Production Loss



# HRS: Value of Production Loss



# Value of Soft Wheats Production Loss