Crop Insurance Panel
2021 CAS Reinsurance Seminar

Jim Konstanty, PartnerRe

Avery Cook, Hudson Insurance Group

Moderator: Jeff Dollinger, PartnerRe

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Audience Poll Question #1

- Do you have experience working in Crop Insurance?
  - Yes
  - No

Audience Poll Question #2

- What is the nature of your experience?
  - None
  - Limited
  - Pricing
  - Reserving
  - Broking
  - Underwriting
  - Other

Audience Poll Question #3

- What is the geography of your experience?
  - None
  - US Only
  - US & International
  - International Only

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CAS Reinsurance Seminar – 2021
Crop Insurance Panel – US Overview

Jim Konstanty, ACAS, Senior Underwriter Agriculture

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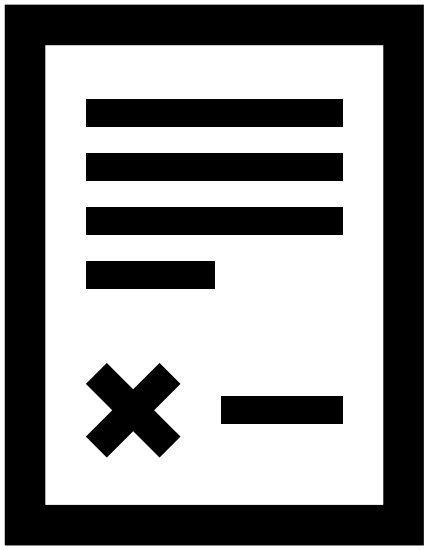
Crop Insurance Products

- Crop Hail
- MPCI
- Named Peril

CROP HAIL INSURANCE

- Covers losses due to hail, fire, lightning, and transit to first site of storage
- Private industry product – no government subsidy or rate setting
- A policy can be purchased at any stage during the growing season up to the anticipated harvest date and subject to minimum lead times (as long as the crop has not already been damaged by hail)



CROP HAIL INSURANCE – con't

- Approval of rates and forms by state insurance departments
- The amount of coverage is purchased on a per-acre basis
- Limited to the expected value of the crop
- Rates can vary by township

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BIG HAIL

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HAIL ON CORN

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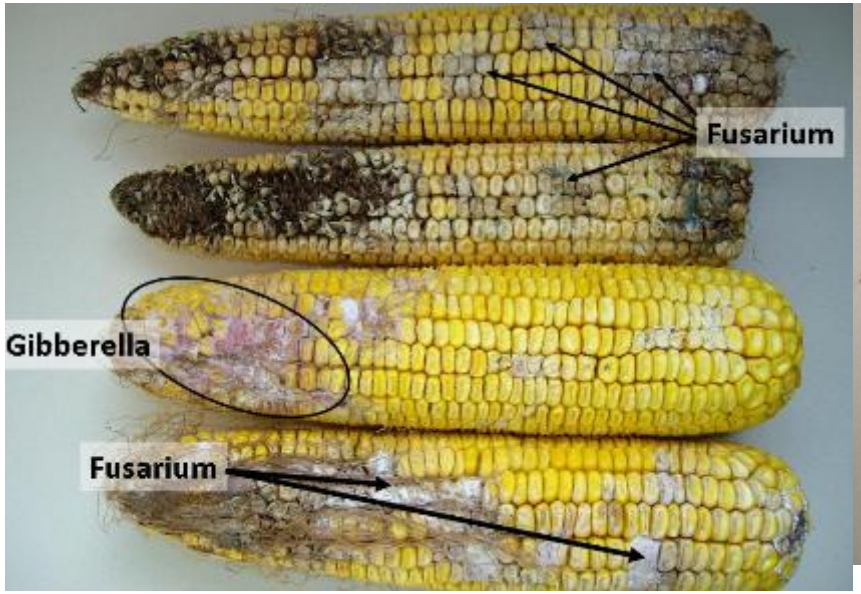
HAIL ON CORN



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HAIL ON WHEAT

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CROP HAIL INSURANCE

PROS

Excellent statistical data available

Proven products & loss adjusting techniques

Limited susceptibility to catastrophic events

Low aggregation potential

Ease of administration (reinsurance)

CONS

Somewhat depressed primary **pricing –** at times written as accommodation to brokers to get more MPCI business

Limited cash flow to Reinsurers

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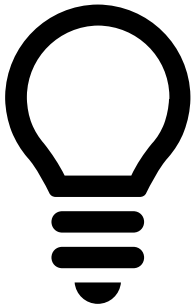
THE BIRTH OF AN IDEA

I have sometimes thought that it might be well to establish an office of insurance for farms against damage that may occur to them from storms, blight, insects, etc. A small sum paid by a number would repair such losses and prevent much poverty and distress.



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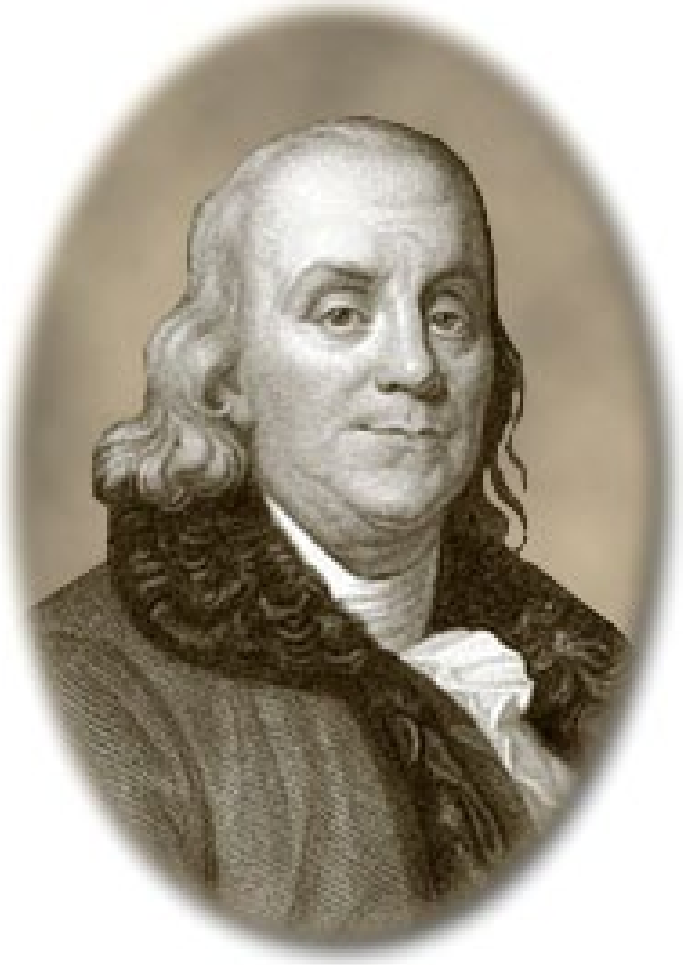

Benjamin Franklin
(1706-1790)

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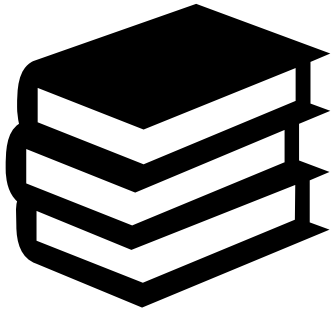
MPCI - ALPHABET SOUP



APH = DNA

The building block of all coverages

MPCI/RP/HPE/ARC/PLC

SRA/AIP/A&O

Not phone services or cable channels

USDA/RMA/FCIC/FSA/NASS

Your tax dollars at work

MULTI PERIL CROP INSURANCE (MPCI)

Provides comprehensive protection against weather-related causes of loss and certain other unavoidable perils

Coverage is available on over 130 crops in primary production areas throughout the U.S.

Coverage levels vary from 50 to 85 percent of the actual production history (APH) for the farm

MPCI coverage provides protection against low yields as well as prevented planting, late planting, and replanting costs for most crops

MULTI PERIL CROP INSURANCE (MPCI)

Revenue/yield blend products are available on major crops to provide additional financial stability to the farmer

Minimum Catastrophic Risk Protection (CAT) coverage is available (pays out after losses of 50% of APH) for $100 processing fee per crop

CORN

CORN DROUGHT

SOYBEANS

SOYBEANS

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SOYBEAN DROUGHT

FLOOD

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EXCESS MOISTURE

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CORN FLOOD

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LOCUST

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LOCUST DAMAGE

SOYBEAN RUST

CROP CIRCLE

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NAMED PERIL PRODUCTS

Continuing development to insure crops outside MPCI coverage

Crop and peril specific (citrus freeze, tomato rain)

Used as marketing tool to obtain more attractive MPCI

Highly leveraged products with erratic experience

Private sector production/insurance/reinsurance

AGGREGATION ANALYSIS

Limited aggregation with P&C portfolio

Crops not susceptible to earthquake

Possible aggregation with tornados as accompanying hail is not uncommon, normally very localized

Limited crop writings in the southeast mitigate aggregation with hurricane exposure

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THE ROLE OF GOVERNMENT IN MPCI

THE ROLE OF GOVERNMENT IN MPCI

- The Federal Crop Insurance Corporation (FCIC) promotes the national welfare by improving the economic stability of agriculture.
- Provides the means for research and the experience necessary in devising and establishing crop insurance.
- The corporation takes actions necessary to improve the actuarial soundness of Federal multi peril crop insurance.
- FCIC also provides reinsurance (subsidy) to approved commercial insurers.
- Since 1998, the private insurance companies reinsured by FCIC have sold and serviced all MPCI authorized under the Federal Crop Insurance Act.

THE ROLE OF GOVERNMENT IN MPCI – Part II

THE ROLE OF GOVERNMENT IN MPCI – Part II

- The Risk Management Agency (RMA) was created to administer FCIC programs and other related risk management programs that help support U.S. agriculture
- In 2000, Congress enacted legislation that expanded the role of the private sector allowing entities to participate in conducting research and development of new insurance products and features.
- RMA can enter into contracts or create partnerships for research and development of new and innovative insurance products.

THE ROLE OF GOVERNMENT IN MPCI – Part III

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THE ROLE OF GOVERNMENT IN MPCI – Part III

- Provides for significant premium subsidies to participating farmers
- Entices more profitable farms in favorable areas to participate in the program
- Current participation exceeds 80%
- Limits catastrophic potential via reinsurance pool cessions

THE ROLE OF GOVERNMENT IN MPCI

Impact of Federal reinsurance agreement

COMPANY SHARE OF UNDERWRITING GAIN/LOSS

L/R	Assigned Fund	Commercial Fund	
		State Group 1	State Group 2
<50%	3.0%	5.0%	5.0%
50 - 65%	13.5%	40.0%	40.0%
65 - 100%	22.5%	75.0%	97.5%
100 - 160%	(7.5%)	(65.0%)	(42.5%)
160 - 220%	(6.0%)	(45.0%)	(20.0%)
220 - 500%	(3.0%)	(10.0%)	(5.0%)

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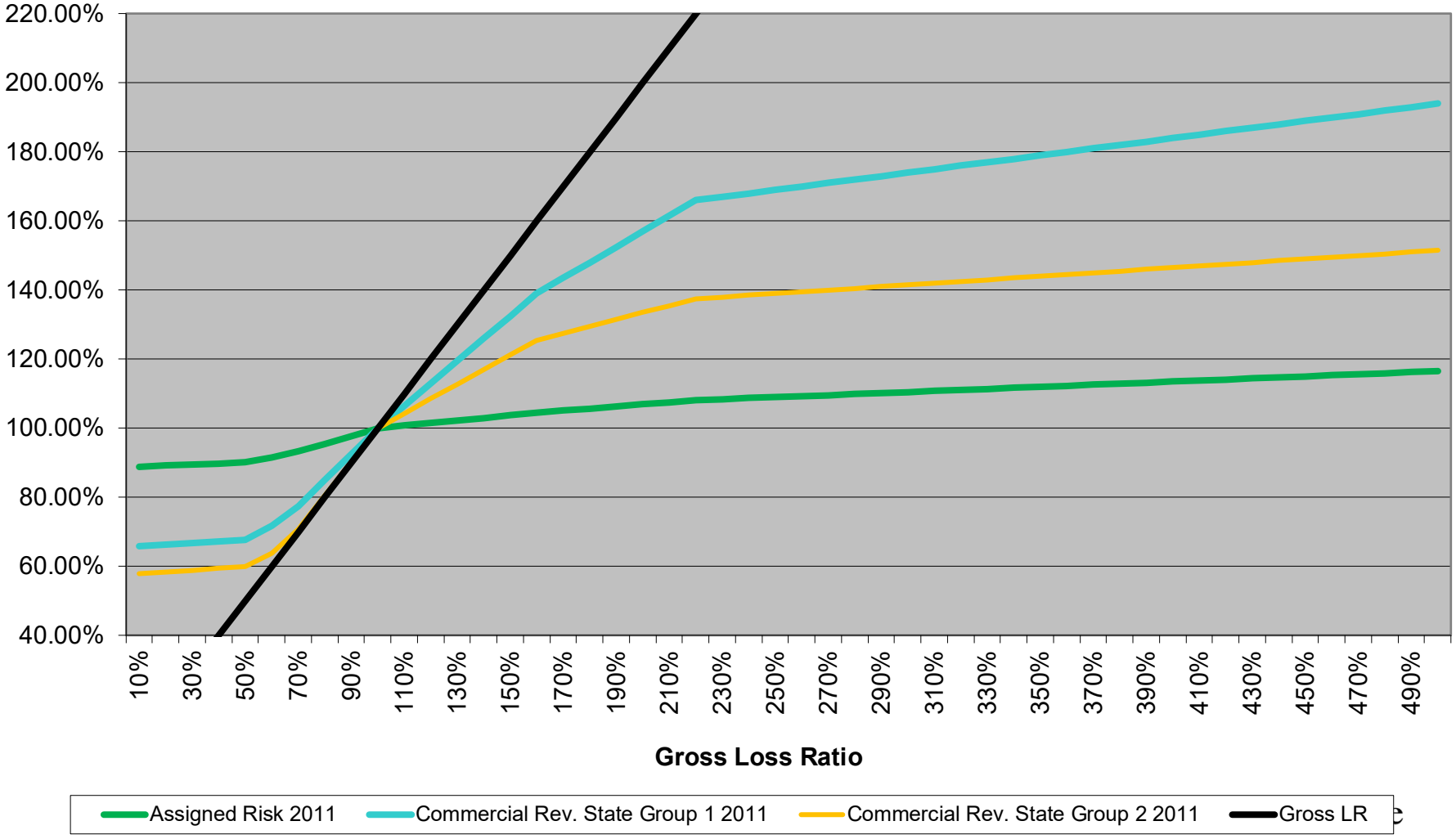
2011 SRA RETAINED LOSS RATIOS

2011 SRA – Gross to Net LRs by Fund



MPCI – FCIC "reinsures" in multiple ways

AIPs choose how much they cede outright to FCIC

FCIC limits the potential loss ratio through the SRA

AIPs must cede 6.5% of their net retained premium and losses

HOW DOES THIS WHOLE PRIVATE/PUBLIC PARTNERSHIP WORK?

Farmers purchase MPCI coverage from agents

Agents place their business with AIPs/SRA holders

- There are 13 SRA holders that control the total US MPCI market – AIP's cannot decline risks

•Premiums paid by farmers are determined by RMA

- Based on commodity price, volatility of futures prices, and the type of coverage purchased(revenue/yield/CAT)

AIPs decide how much business they place in each SRA fund with minimums and maximums applying

SRA determines how FCIC responds to loss ratio results

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SRA – HOW DOES IT WORK?

- Commercial Fund
  - Formula applies differently for each of the 2 state groups
  - Formula is applied to each state individually
  - Limits your gains in good years
  - Limits your losses in bad years
  - Assigned Risk Fund
  - Formula applies the same way for each state

FORMS OF REINSURANCE PURCHASED BY AIPs

- MPCI QS
- Crop Hail QS
- Named Peril QS
- MPCI Aggregate Stop Loss
- Crop Hail Stop Loss

WHO ARE THE AIPs?

AFBIS, INC.
American Farm Bureau Insurance Services, Inc.

AgriSompo North America

COUNTRY Financial

Crop Risk Services
An AIG company

Farmers Mutual Hail Insurance Company of Iowa

Global Ag

Great American Insurance Group
Crop Division

Hudson Insurance Group

NAU Country
A QBE Insurance Company

PRO AG

Precision Risk Management

Rain and Hail
A Chubb Company

RCIS

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MULTIPLE PERIL CROP INSURANCE

- A/K/A “Multi Peril” or “MPCI”
- In addition to Hail, Fire, Wind, covers natural perils including:
  - Drought
  - Flood
  - Insect Infestation
  - Levee Dynamiting (2011)
- Covers loss of:
  - Production, as in it covers a percentage of a farmer’s average yield
  - Revenue, as in it covers a percentage of a farmers expected Revenue = (yield x commodity price)
- RMA sets rates and writes policy wording.
- Written only by 13 Approved Insurance Providers (AIP’s)
- Estimated GWP $10.1bn in 2020.

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Source: Markel Corporation

COVERAGE LEVEL: 2014 Example

Corn - Base Price $4.62 (avg Feb futures price)

MPCI/APH (about 10% of all policies by prem in '20)

150 x 80% = 120 x $4.62 = $554.40

APH Yield x Coverage % = Guaranteed Bushels/Acre x Price = Insurance per Acre

Actual Production 100 x $4.62 = $462.00

Indemnity $92.40

COVERAGE LEVEL: 2014 Example

Corn - Base Price $4.62 (avg Feb futures price)

Harvest Price $3.49 (avg Oct futures price)

MPCI / Revenue (about 72% of all policies by prem in 2020)

150 x 80% = 120 x $4.62 = $554.40

APH Yield x Coverage % = Guaranteed Bushels/Acre x Price = Insurance per Acre

Actual Production 120 x $3.49 = $418.80

Indemnity $135.60

COVERAGE LEVEL: 2012 Example

Corn - Base Price $5.68 (avg Feb futures price)

Harvest Price $7.50 (avg Oct futures price)

MPCI / Revenue

150 x 80% = 120 x $5.68 = $681.60

APH Yield x Coverage % = Guaranteed Bushels/Acre x Price = Insurance per Acre

Adjusted covg level = 120 x $7.50 = $900.00

Actual Production = 60 x $7.50 = $450.00

Indemnity $450.00

CATASTROPHE ANALYSIS

Mitigation

80%+ program participation provides excellent spread

FCIC reinsurance severely limits down side in catastrophic years

Better cession practices by private insurers limit exposures

Massive multi-year event needed to approach maximum limits

MULTI PERIL CROP INSURANCE (MPCI)

PROS

Beneficial government reinsurance

Government subsidies on policyholder premium & insurer expenses

Low aggregation potential

Narrow range of results in non-cat year

Rapid recovery from catastrophic losses

High profit commissions on private sector reinsurance

CONS

Limited data available (30 years)

Subject to systemic (catastrophic) loss

Some uncertainty with continuity of Federal reinsurance coverage

Limited cash flow

REINSURANCE COVERAGES AND TRENDS

MPCI

Attractive returns causing consolidation/retention

Large market players tend to purchase stop loss or hedges only

Increase in subsidies pushing up purchase levels but generally cap out at 85% due to cost

Revenue type products now more than 70% of gross MPCI purchased

Companies relying more on ceding and profit commissions as A&O allowances are reduced

Thank you!

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AG INSURANCE PRICING MODELS

6/9/2021

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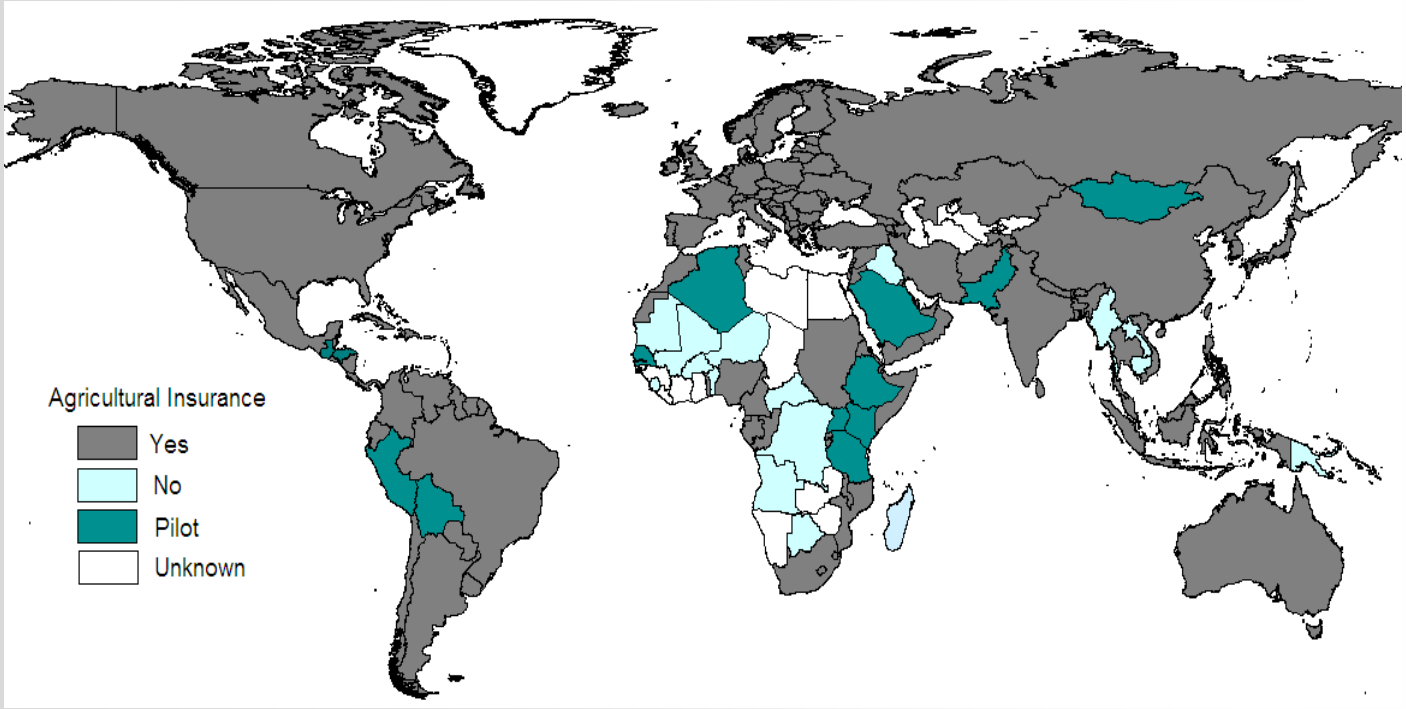
WORLDWIDE AGRICULTURAL INSURANCE

- Increasing population has increased focus on food security and support for Agricultural Insurance programs.
- Agriculture Insurance premiums are expected to double over the next decade



* Some form of crop insurance is available in 104 countries, source world bank

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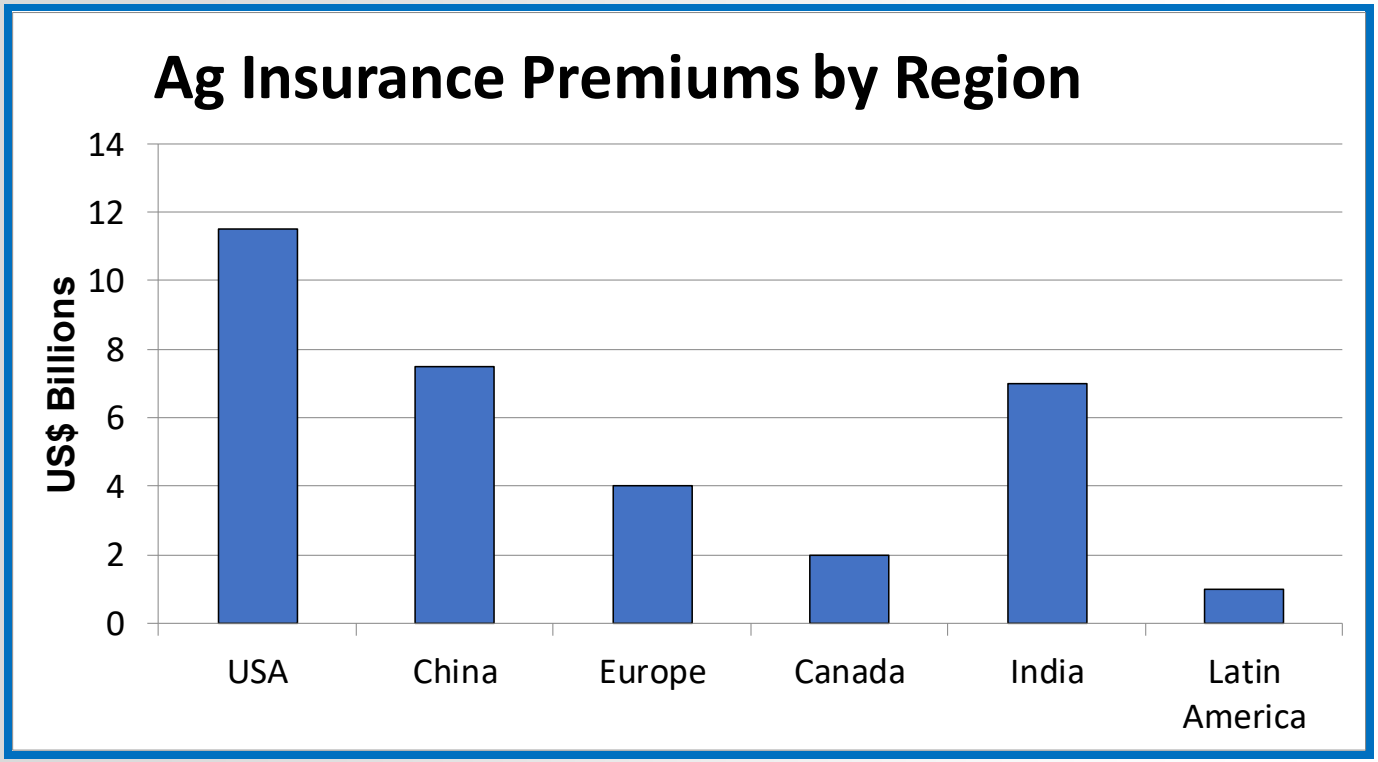
GLOBAL AGRICULTURE INSURANCE PREMIUMS



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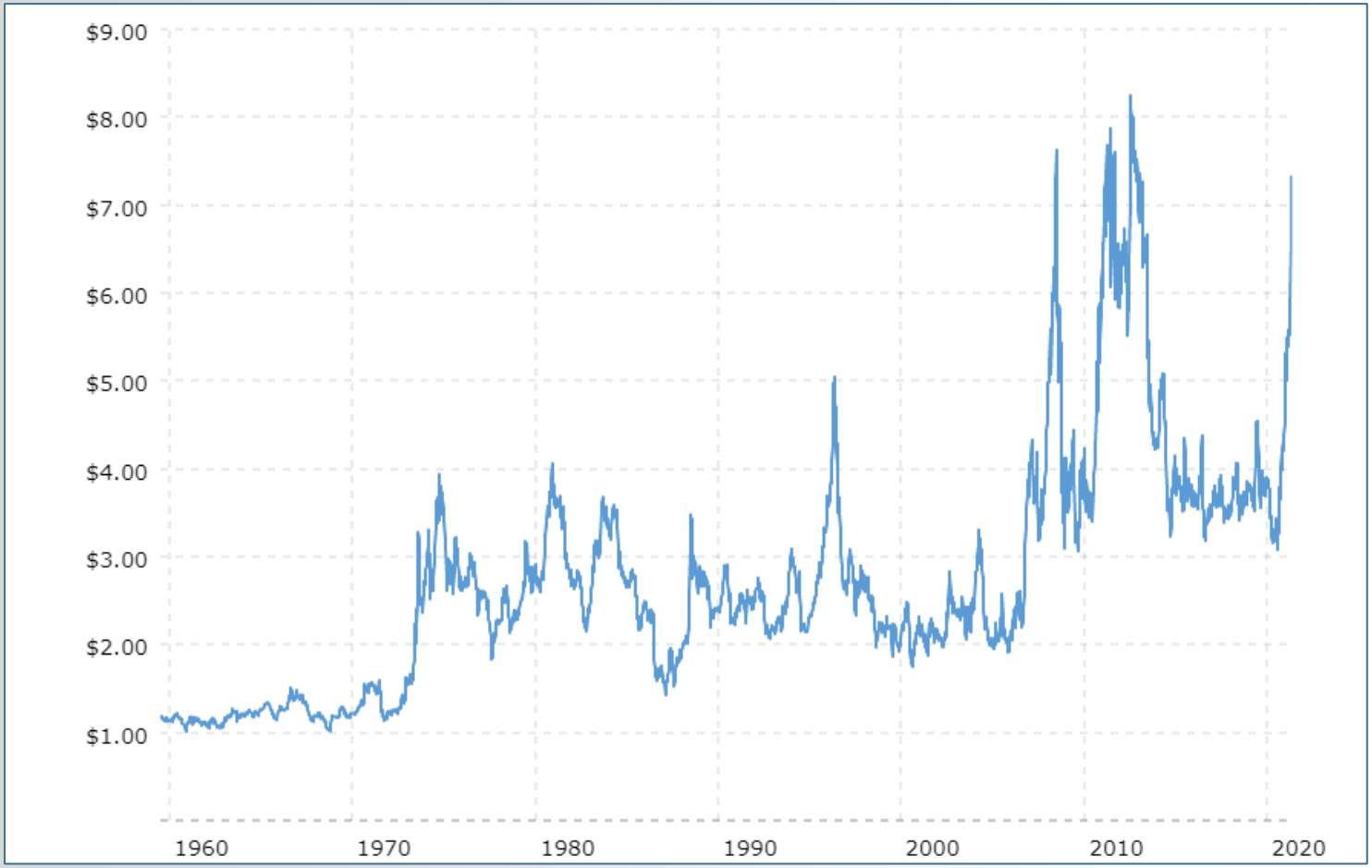
PRICES AND VOLATILITY

- As demand increases prices and price volatility has been increasing for Corn (below) and other agricultural commodities



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WHY BUILD A CROP MODEL?

- Historical Results can have a very limited data period
- A crop model can leverage existing experience data with other data sources
- Historical Results do not reflect today's participation:
  - Product mix/deductible mix
  - Crop Mix
  - Geographic Distribution
  - Program design
- Crop models can also be used to test the impact of potential\hypothetic changes to these factors in advance

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CROP IS UNIQUELY SUITED TO MODELING

- Despite technological improvements the events that cause crop yield loss remain the same
  - Drought, Hail, Frost, Excess moisture, Pests and disease
- Crop yields are one of the longest available data series. Weather information is also widely available.
- Even if you don't build a model, data can help you to answer key questions
  - How often do major droughts or frosts occur?
  - Was 2002 worse than 2012?

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COMMON TYPES OF CROP MODELS

Loss Ratio model

- Fit distributions to historical loss ratios

Growth Model

- Yield is modeled indirectly by using a growth model – ie. a model relating expected plant growth to variables like crop type, variety, soil type, temperature, sunlight and available moisture (rainfall and soil moisture).

Weather to Yield Regression Model

- Yield is modeled based on a regression relationship between yield and weather parameters

Yield based model

- Uses historical yields to establish an expected distribution of future yields and modeling losses based on simulated yields

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LOSS RATIO MODEL

- Information requirements
  - Historical loss ratios by geography and product. The more detailed the better
- Pros
  - data is typically provided in the submission, industry data is often available
  - Generally, the simplest to implement
- Cons
  - Does not reflect changes in product design or deductibles
  - Can be difficult to properly reflect rating impacts due to differences in mix/deductible levels
  - Tendency to reflect conditions which have occurred during the data period which is often selected by the client

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GROWTH MODEL

- Information Requirements
  - Historical yields, rainfall, temperature, sunlight, soil type etc., loss function
- Pros
  - Weather information is often available
  - Reflects a wide variety of perils
  - Trending may not be required
- Cons
  - Weather information is not available at all geographic locations only at weather stations (gridded data etc. can help as long as volatility is maintained)
  - Fairly complex
  - Growth models often fail to predict how crops will perform under some growing conditions (timing)
  - Some perils like pests are difficult to include
  - Can smooth out extreme events need to ensure that volatility is maintained

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WEATHER TO YIELD REGRESSION MODEL

- Information Requirements
  - Historical yields, rainfall, temperature, sunlight, soil type etc., loss function
- Pros
  - Weather and yield information are often available
  - Reflects all perils experienced in the data
  - Can be helpful to extend the data period
- Cons
  - Weather information is not available at all geographic locations only at weather stations (gridded data etc. can help as long as volatility is maintained),
  - Can also fail to predict how crops will perform under some growing conditions (timing)
  - Some perils like pests are difficult to include
  - Can smooth out extreme events need to ensure that volatility is maintained

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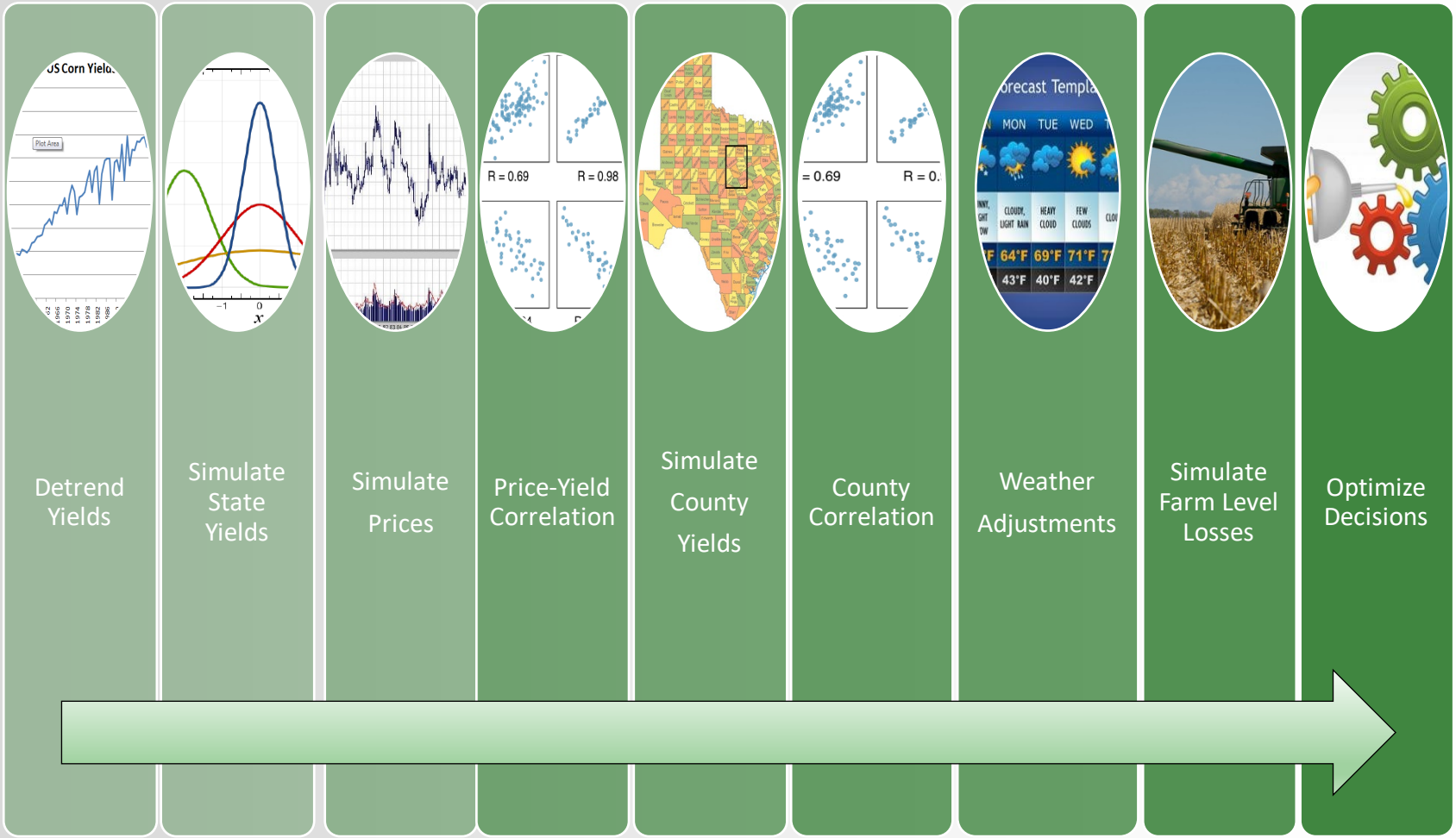
YIELD BASED MODEL

- Information requirements
  - Historical yields and prices (if covered), Loss function
- Pros
  - Yield data is typically available
  - All perils affecting yield are reflected in yield
  - Less tendency to reduce the volatility
- Cons
  - Trending is required to reflect changes in practices, technology etc.
  - Individual farm yields collated by crop, geographic area and farming practice are best, but often unavailable
  - Tendency to reflect conditions which have occurred during the data period

YIELD MODEL OVERVIEW



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MODELING CONSIDERATIONS

- Crop often slants toward the “Cat”
  - ~75 cents of every claim dollar is paid out in a major drought year, making a long-term view of drought risk very important
  - Disasters
    - What was the cause?
    - Do disasters coincide with weather/yield events from public sources?

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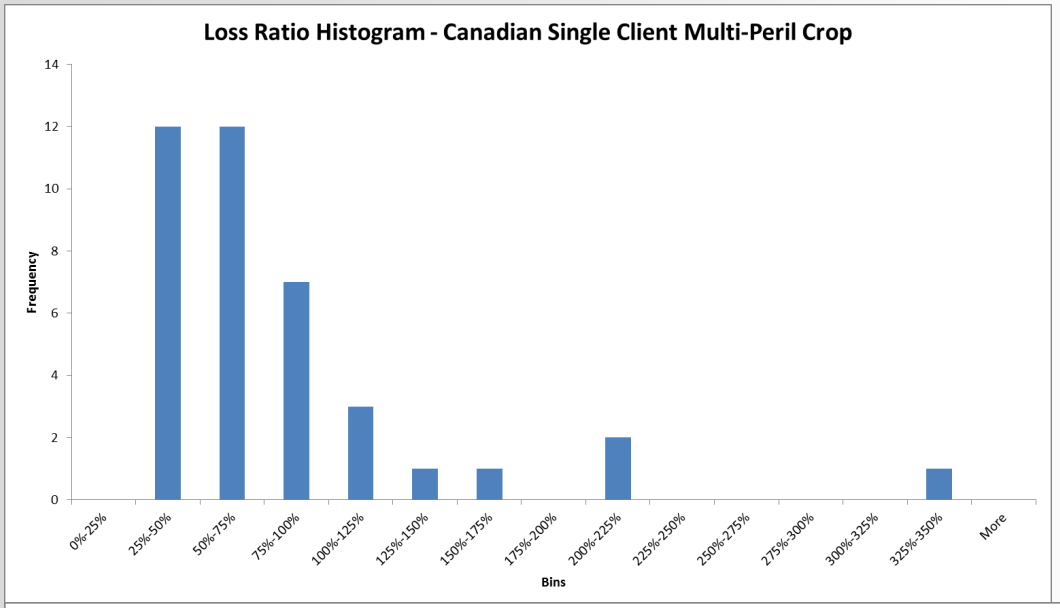
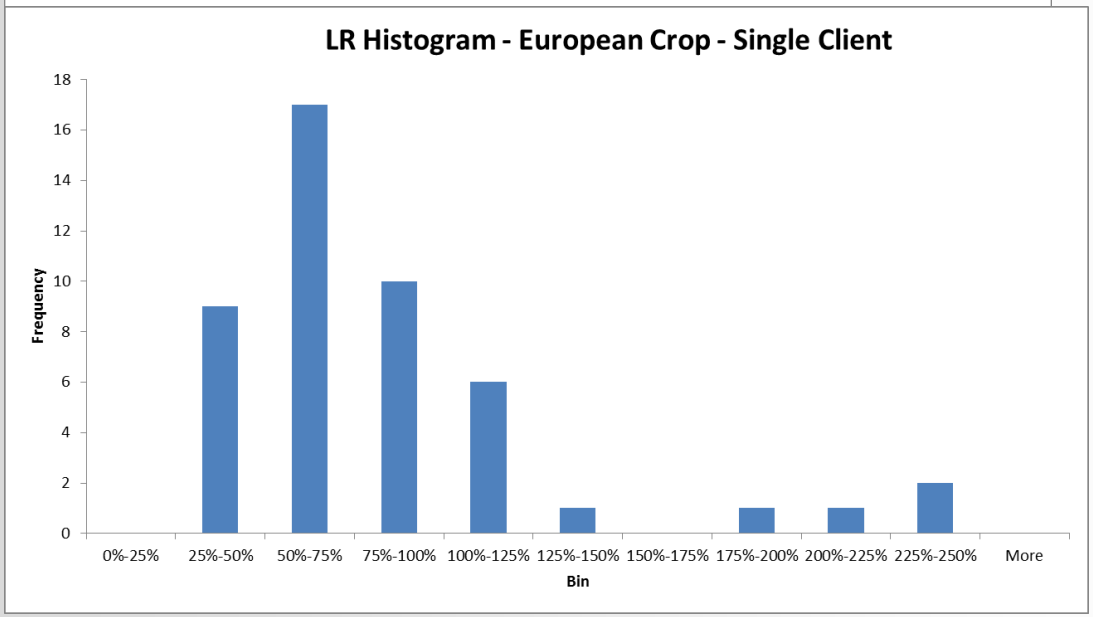
SHAPE OF GROUND UP CURVE





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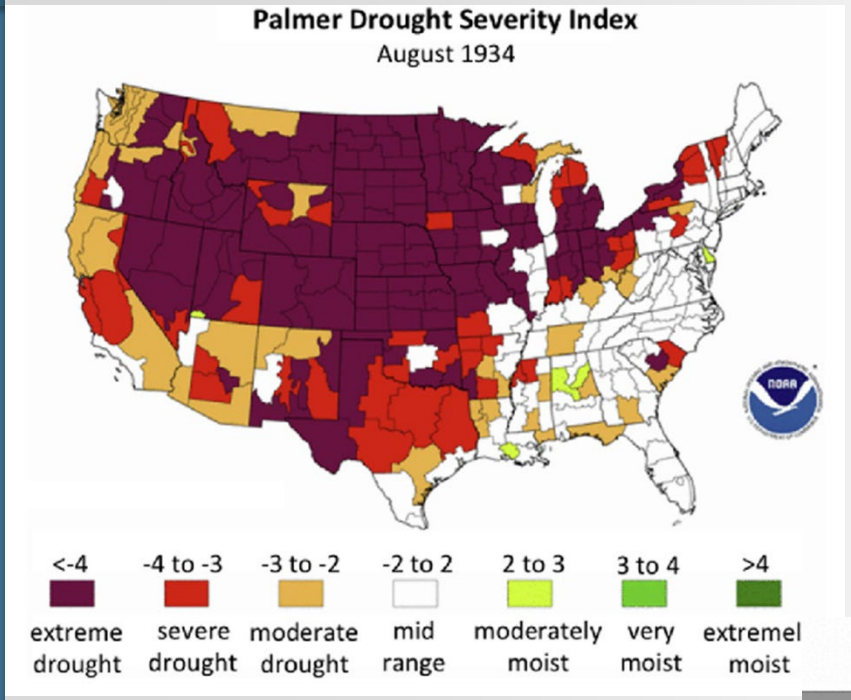
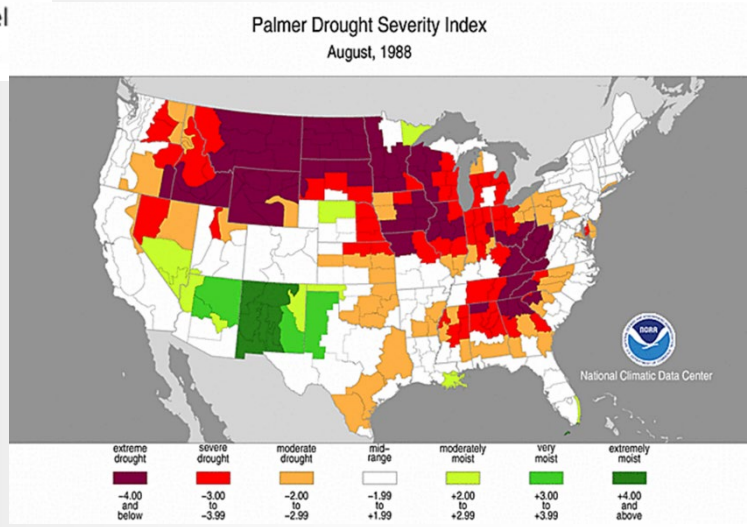
WHAT DRIVES THE TAIL?

- **IT'S HARD TO DIVERSIFY AWAY FROM A MAJOR DROUGHT!**





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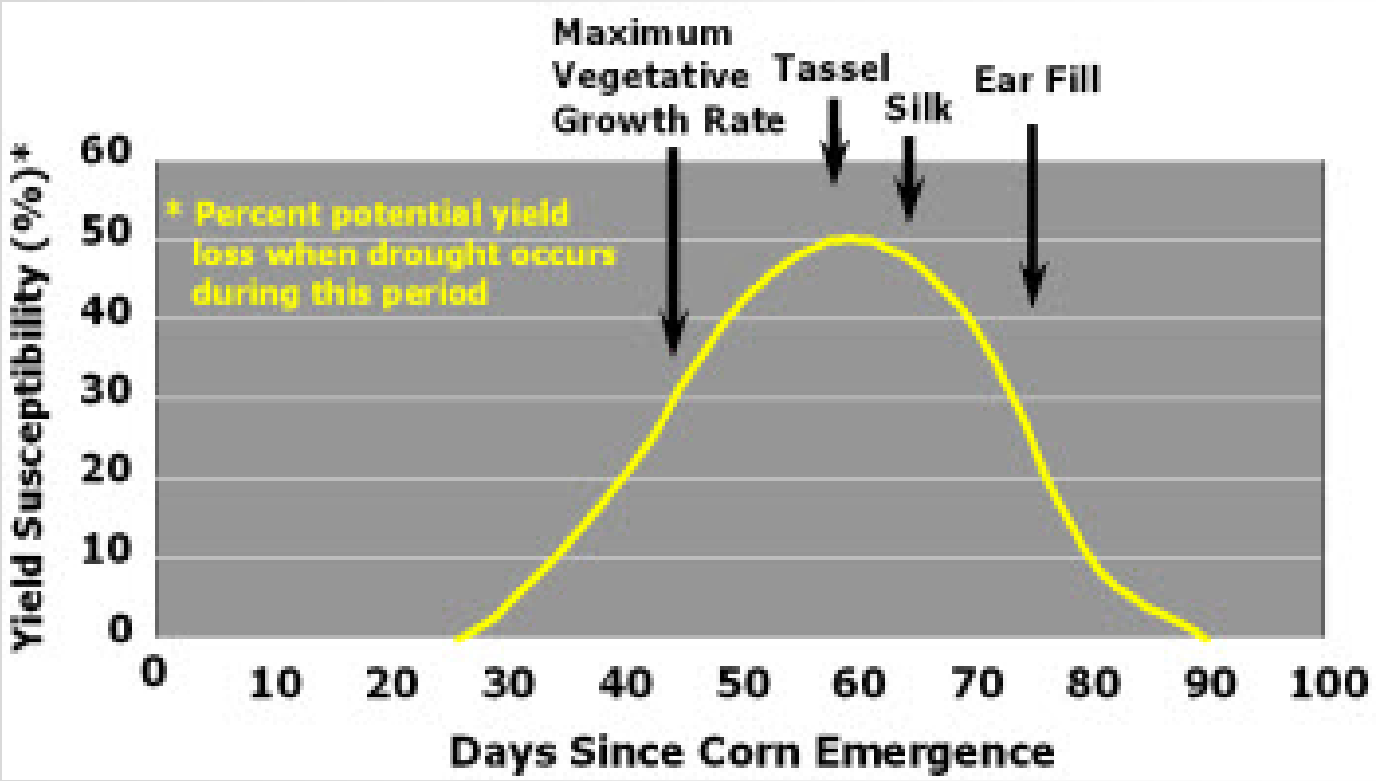
WHAT DRIVES THE TAIL? TIMING MATTERS



https://www.pioneer.com/home/site/us/agronomy/library/corn-irrigation-mgmt-limited-water-supplies/

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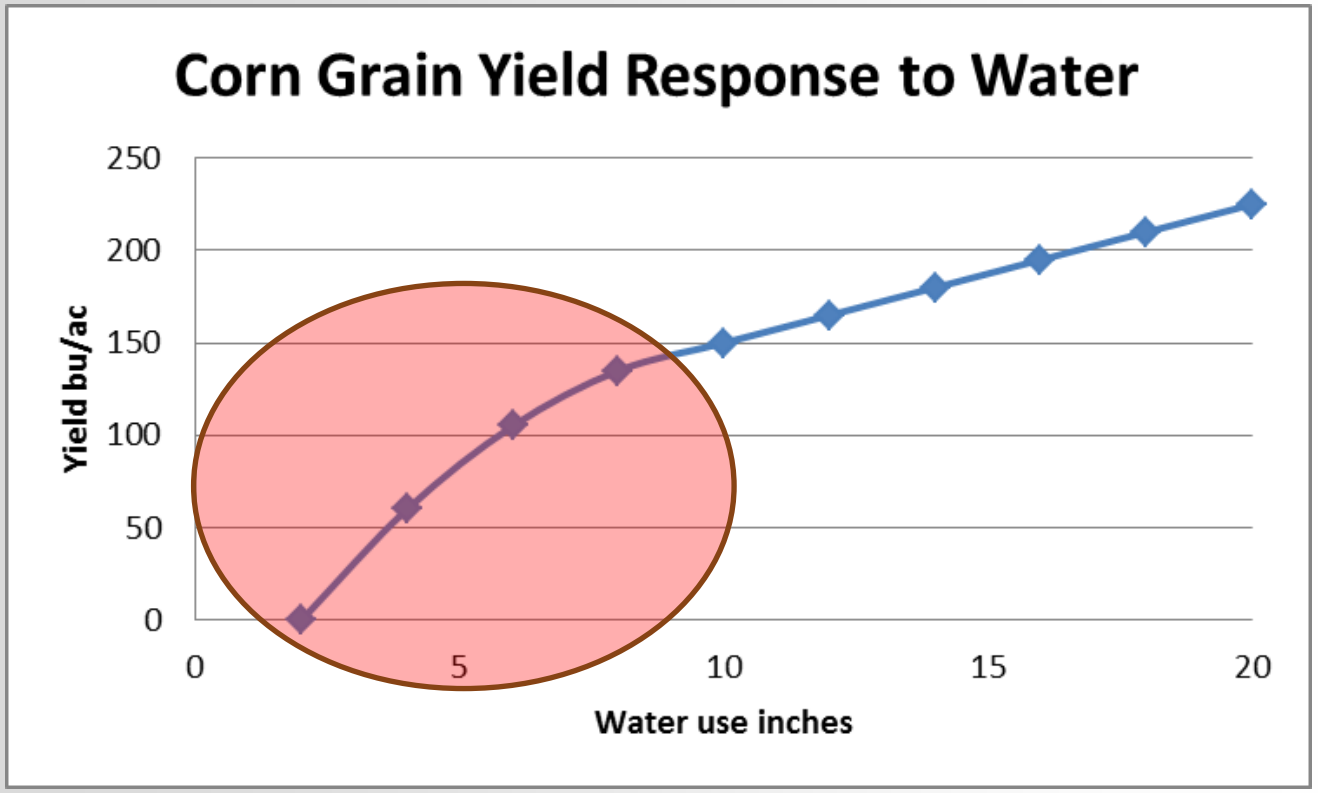
WHAT DRIVES THE TAIL? MORTALITY TIPPING POINT



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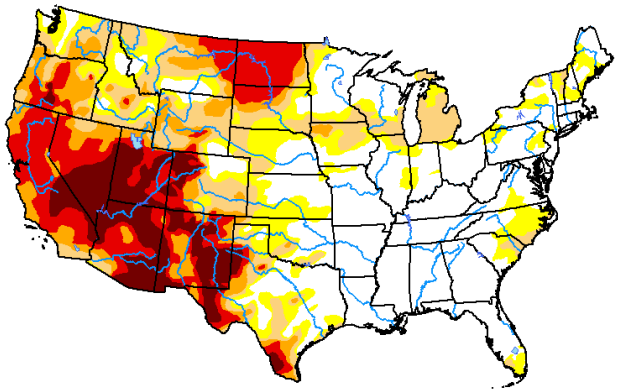
MODELING CONSIDERATIONS

- Weather forecasts and current conditions?
  - Do results seem to be worse in El Nino or La Nina years?
  - Is current soil moisture exceptionally high or low?
  - Is irrigation water available this year?
  - What do we know about the health of perennial/winter crops?



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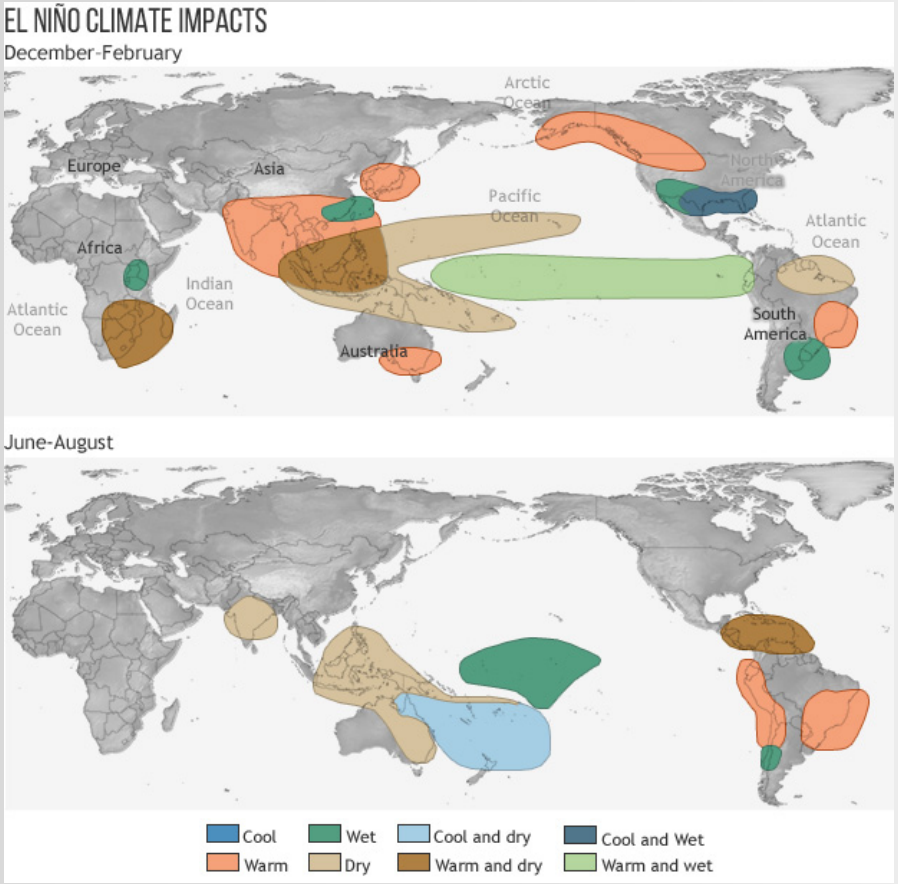

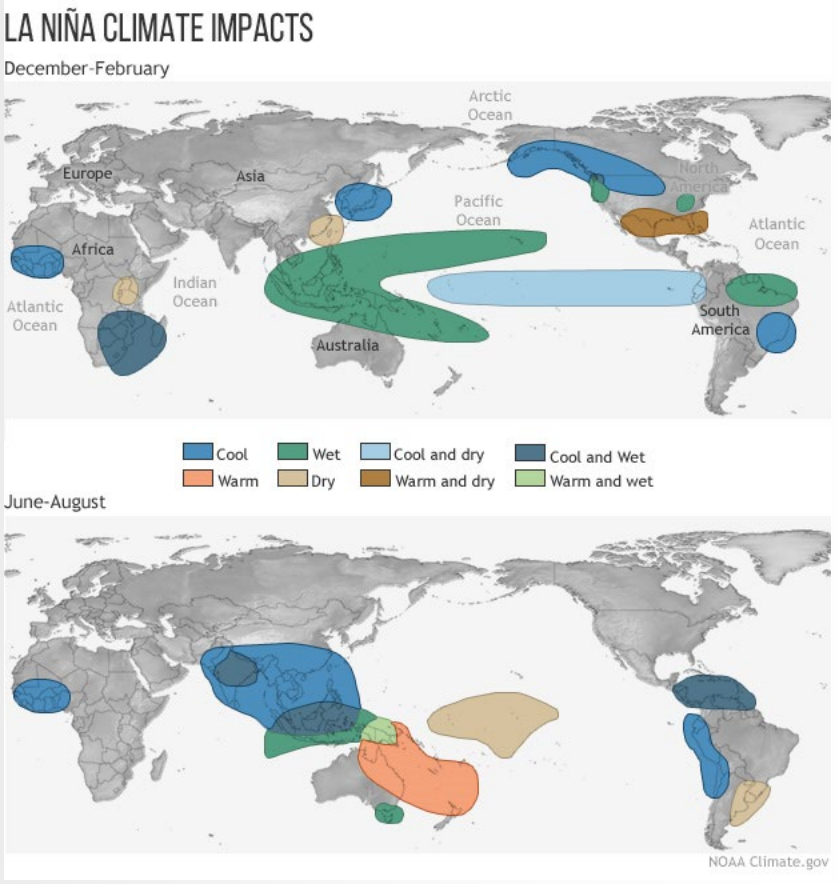

Source : Figure 2: Impacts of El Niño on crop yield anomalies for four crops. | Nature Communications

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PRODUCTS INVOLVING COMMODITY PRICES

- How are the strike and settlement prices set?
  - Beware of price/revenue products with coverages based on historical averages. These can be “in the money” relative to the forecasted price at the start of the sales season
- Exchange info:
  - What is the forecasted futures price for the main crops?
    - How does this compare to coverage?
  - Is volatility high or low relative to past years?
    - Is this accounted for in rating?
- USDA (World Agricultural Supply and Demand Estimates, Foreign Agriculture Service reports)
  - These reports can help you to understand major concerns that might impact prices

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ADVERSE SELECTION

- Farmers know a lot about their farm
  - Soil moisture on every field
  - The current health of perennial crops
  - Seasonal forecasts and their local impacts
  - The new variety they plan to plant is riskier
  - Conditions are ripe for pests
  - Etc.

- Watch for higher participation in years with higher loss!

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EXAMPLES OF ADVERSE SELECTION /MORAL HAZARD

- Australian farmers know that yields in El Nino years are approximately ½ of those in neutral year.
- Some countries pay crop loss adjusters with a fee calculated as a % of the assessed loss
- Loss adjusting livestock mortality based on the return of irremovable tags from the ears of cattle
- In India cedants negotiate reinsurance terms before they bid on business.
- Many crop insurance programs start by allowing farmers to bring in proof of historical yields to set coverage. Some how bad years are never provided.

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THE INTERACTION OF US MULTI-PERIL CROP INSURANCE COVERAGE AND PREMIUM RATES AND IT'S IMPACT ON EXPECTED LR

- Coverage
  - Coverage for each farmer is set based on average historical yield so coverage increases after good years and decreases after bad years
- Premium Rates
  - Primary rates increase after bad years and decrease after good years

The table below show the ~10% increase in expected LR for a farmer after a good year (a 3% increase in coverage and a 3% decrease in rate)

Impact of Premium and Coverage Changes at 80% Coverage

Year	Guaranteed Yield	Coverage $/ac	Expected Loss	Expected LC	Premium Rate	Expected LR
Last Year	148.8	$ 669.60	$ 56.87	8.49%	12.00%	70.77%
This Year	153.6	$ 691.20	$ 62.72	9.07%	11.64%	77.96%

*Impact on expected loss assessed with the calibrated normal theory model

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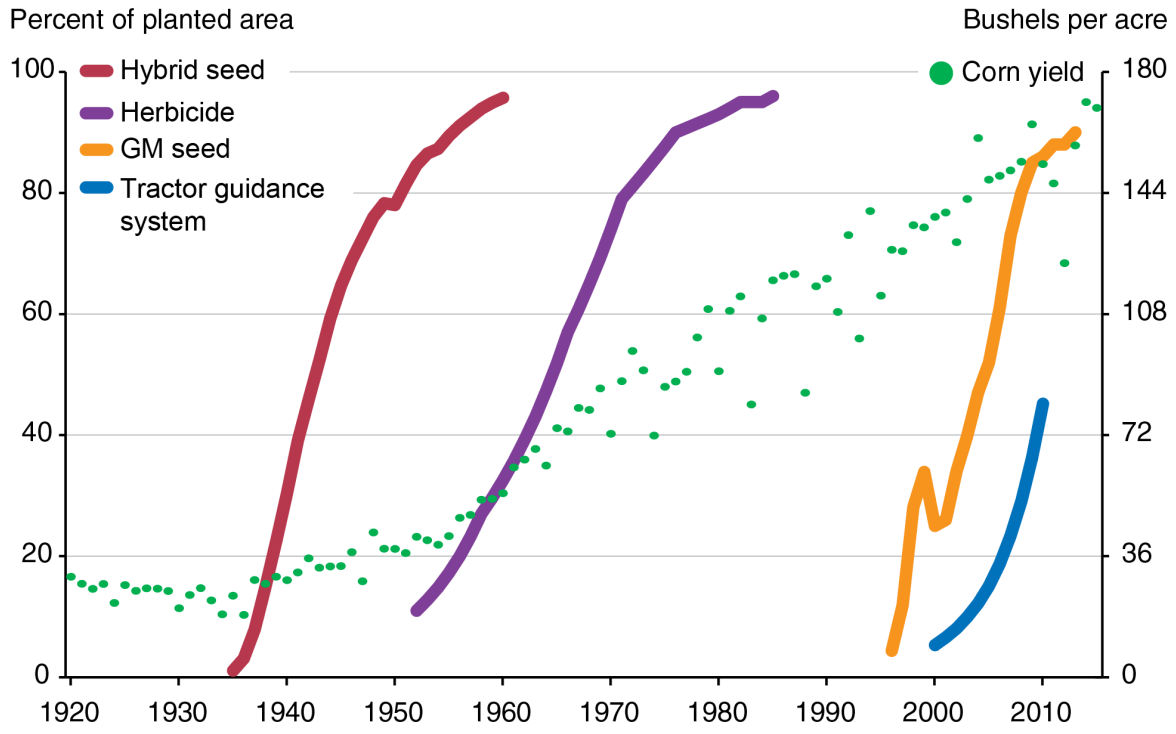
DOES TECHNOLOGY IMPROVEMENT REDUCE CROP INSURANCE RISK?

Effect on corn yields as different innovations become adopted, 1920-2014



Note: GM = genetically modified.
Source: USDA, Economic Research Service analysis using data from the National Agricultural Statistical Service, Agricultural Statistics yearbook and the Agricultural Resource Management Survey.

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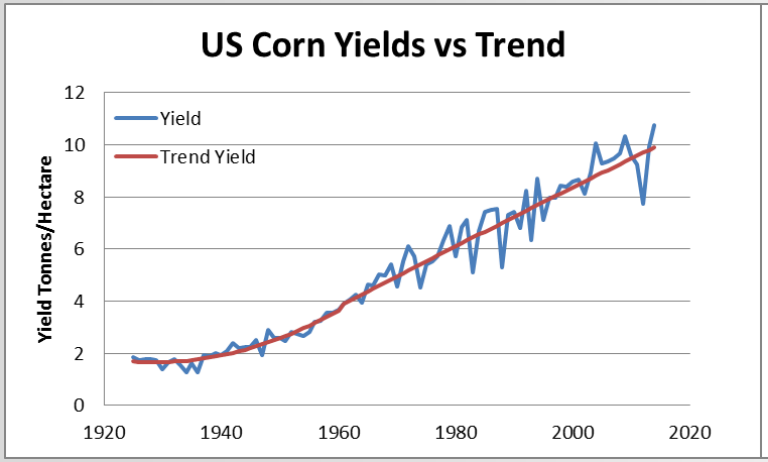
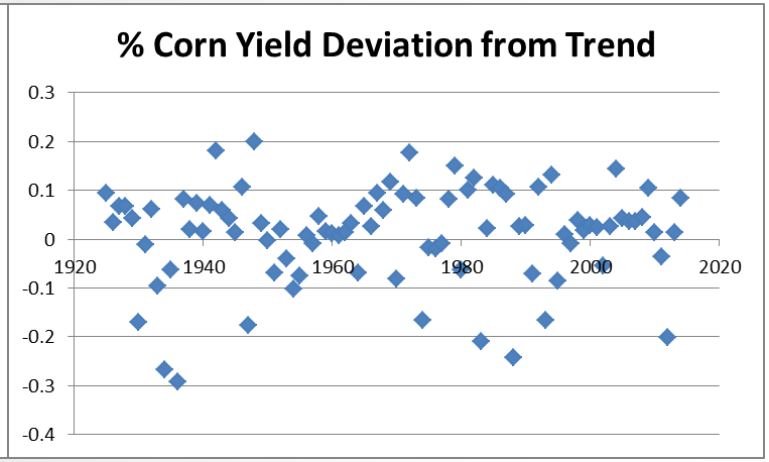
QUESTION 1: HAS THE VOLATILITY OF YIELD AROUND TREND CHANGED?





Decade	1	2	3	4	5	6	7	8	9
Average Abs Deviation	9.08%	8.96%	7.61%	2.86%	9.60%	7.97%	10.78%	4.36%	6.10%
Minimum Deviation	-26.64%	-29.13%	-17.62%	-7.61%	-16.53%	-20.95%	-24.21%	-8.65%	-20.05%

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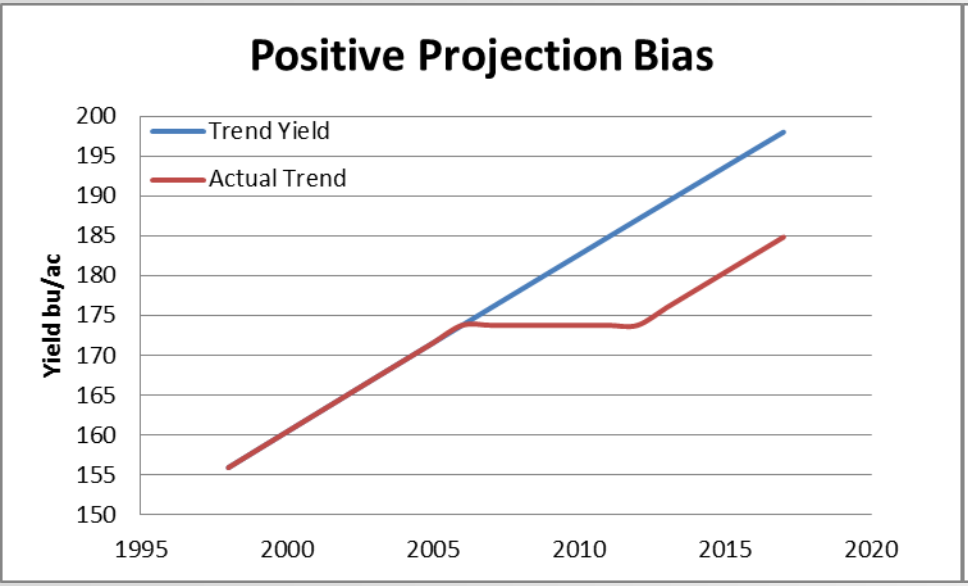
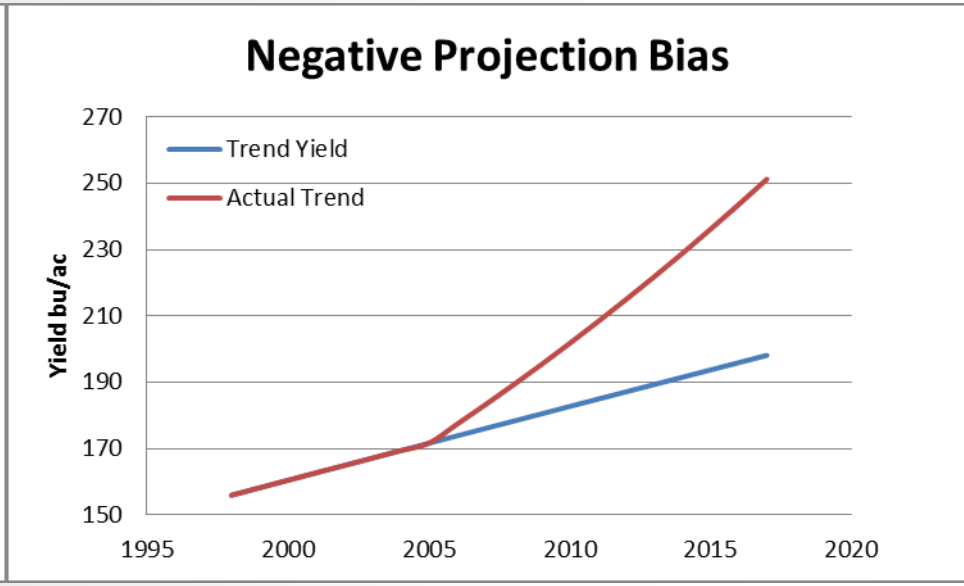
QUESTION 2: HAS THE LEVEL OF PROJECTION BIAS CHANGED?

- At the farm level technological improvements occur in steps (the new technology is either taken up or not). At an aggregate level this is smoothed out
- The expected future loss ratio can be increased or reduced based on the interaction of actual yield trend and the trend method used to set primary coverage.





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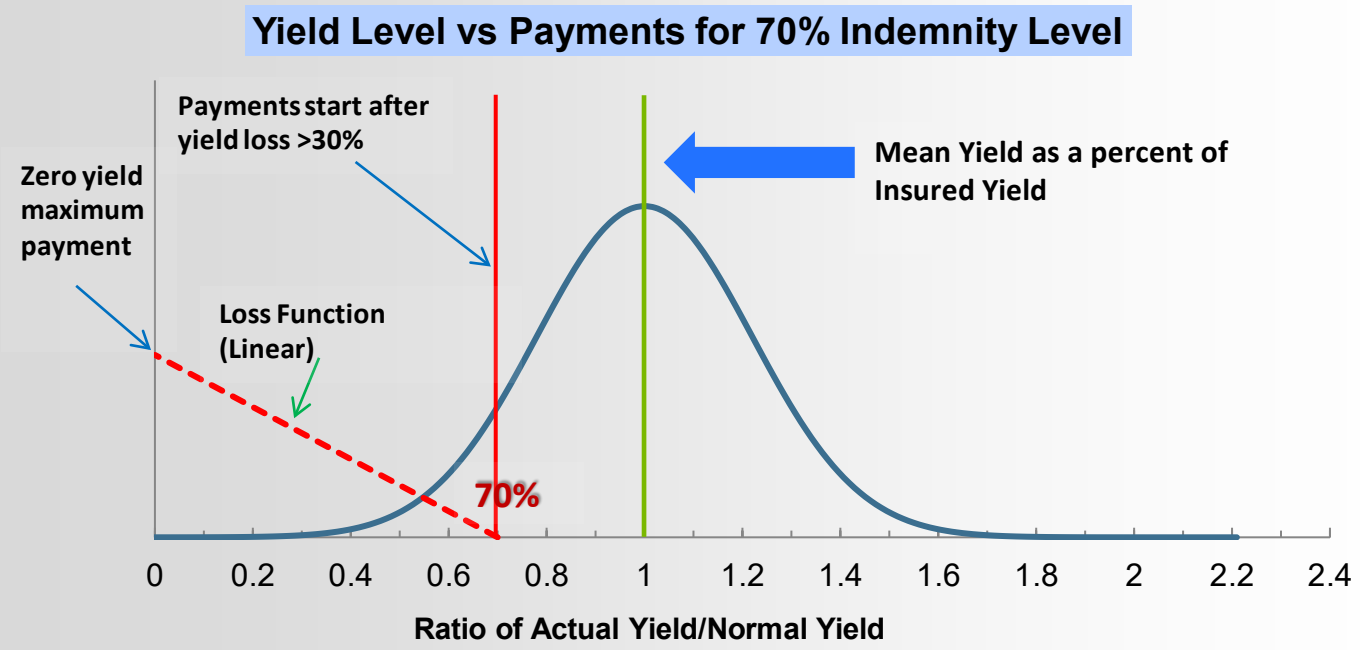
CALIBRATED NORMAL THEORY MODEL

- The Normal Theory Model (NTM) estimates losses based only on the guaranteed yield and the mean and standard deviation of yields
- The accuracy of the NTM can be improved by calibrating the standard deviation so that the modeled loss matches the actual loss using a known mean yield level ie. from NASS
- Although yield are not normally distributed the “Calibrated NTM” has been tested and generally performs as well as fitting individual distributions to yields



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NORMAL THEORY MODEL USES

- The NTM can be used for a wide variety of analysis:
- Estimating the impact of a change in the method of setting coverage
  - i.e. Introduction of trending to the US program
- Adjusting LR's for a change in deductible levels
- Back casting results for years where insurance results are not available, but you have yield data.
- Introduction of quality coverage or revenue insurance to a yield-based program
- Converting crop conditions reports into loss forecasts by state, or projecting yield-based loss forecasts to a revenue insurance loss forecasts based on current futures info
- Offering area-based coverage at a less aggregate level

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HELPFUL LINKS/INFO

FORMULA FOR NTM

- Standard NTM Formula
- Estimated Loss Cost= $((G-Y)\Phi((G-Y)/\sigma) + \sigma \phi ((G-Y)/\sigma))/G$
- Where
  - G = the Guaranteed yield (covered yield based on primary terms)
  - Y = the average yield for the year of interest
  - σ = the standard deviation in yield for the year of interest
  - $\Phi(x)$ = the standard normal CDF
  - $\phi(x)$ = the standard normal PDF
  - *Parameters for this formula can be converted to percentage terms by dividing the parameters by 100% of the Insured Yield= G/(1-Deductible%). This is often equal to the LTA yield but should be adjusted to includes any known bias involved in the coverage setting process.

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DATA SOURCES - WEATHER

Forecasts

http://www.cpc.ncep.noaa.gov/products/international/nmme/html_seasonal/precip_anom_sasia_body.html

http://www.jamstec.go.jp/frcgc/research/d1/iod/e/seasonal/outlook.html

ENSO

http://ggweather.com/enso/oni.htm

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web.pdf

http://www.bom.gov.au/climate/poama2.4/poama.shtml

India

http://www.imd.gov.in/pages/monsoon_main.php

Data

https://www.ncdc.noaa.gov/ghcnm/v2.php

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MARKET INFO

US

https://www.agweb.com/markets/

http://www.doane.com/

Global

https://www.fas.usda.gov/

https://gain.fas.usda.gov/Pages/Default.aspx

https://www.usda.gov/oce/commodity/wasde/

http://www.thecropsite.com/news/vars/country/

China

http://www.cropwatch.com.cn/htm/en/index.shtml

Europe

http://www.europeangrain.com/

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DATA SOURCES - CROP AND LIVESTOCK

US

https://www.nass.usda.gov/Data_and_Statistics/index.php

https://www.rma.usda.gov/data/sob.html

India

http://aps.dac.gov.in/APY/Public_Report1.aspx

China

http://zzys.agri.gov.cn/zaiqing.aspx

Livestock disease

http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/diseasehome

World

http://www.fao.org/faostat/en/#data/QI

Australia

http://www.abs.gov.au/ausstats/abs@.nsf/mf/7124.0

Europe

http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_production_-_crops

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DROUGHT MONITOR AND SOIL MOISTURE SITES

US

https://www.usda.gov/oce/weather/pubs/Weekly/Wwcb/wwcb.pdf

India

http://www.monsoondata.org/wx2/soil.html

Global

https://www.star.nesdis.noaa.gov/portfolio/productCatalog.php

http://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/

https://gis.ncdc.noaa.gov/maps/ncei/drought/global

Canada

http://www.agr.gc.ca/DW-GS/current-actuelles.jspx?lang=eng&jsEnabled=true

http://www.agr.gc.ca/eng/programs-and-services/drought-watch/canadian-drought-monitor/?id=1463575104513

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