Advancements of the U.S. Egg Industry from 1960 to 2010: Productivity, Resource Utilization, and Environmental Footprint

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A Presentation to GRA on Agricultural Greenhouse Gases

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U.S. & Iowa Egg Industry

- ✓ U.S. human population: 319 M (2014)
- ✓ U.S. laying hens: 305 M (March 2015), 270 M (June 2015) due to AI outbreak
- ✓ U.S. eggs production: 87 B/yr
- ✓ Per-capita egg consumption: 263 eggs/yr
  - 69% shell eggs & 31% processed eggs
- ✓ 94% of eggs produced in conventional cage housing systems
- ✓ Iowa laying hens: 59/34.3 M (Mar/Jun'15)
- ✓ Iowa eggs production: 16.3 B/yr (2014)

Presentation Outline

I. Rationale, Objectives, Methodology and Results of the “50-year Study”

II. Drivers responsible for the observed changes in environmental footprints

III. Opportunities for further improvement

IV. Summary

I. Rationale, Objectives, Methodology and Results of the “50-year Study”

Rationale

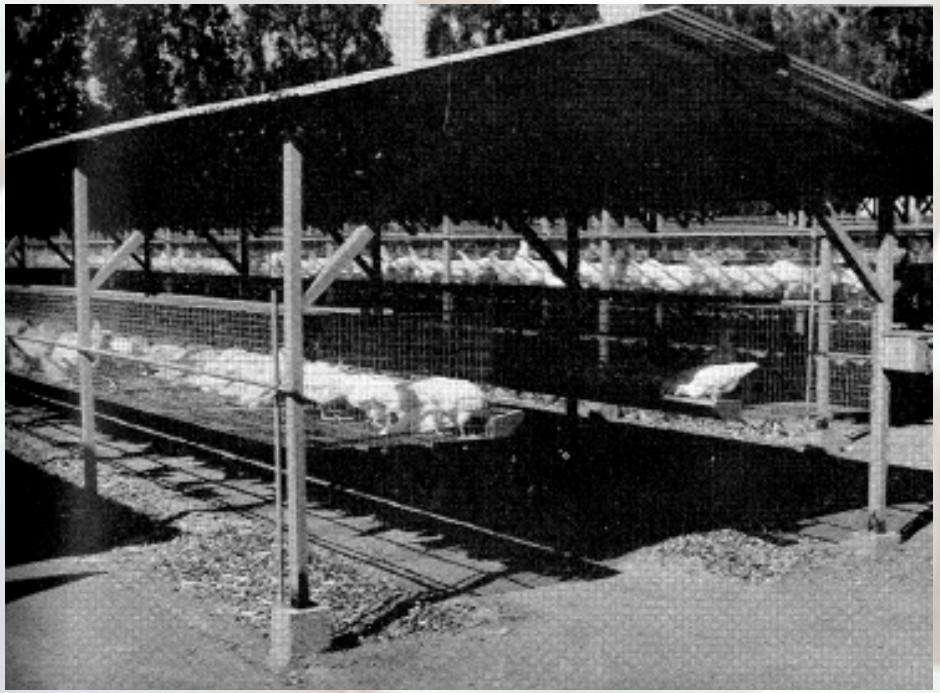
- Remarkable advancements made in the U.S. egg production
- No assessment of environmental footprint affected by such advancements
- Environmental sustainability is of increasing socio-economic importance.
- An evaluation is warranted.

Objectives

1. Compare 1960 and 2010 U.S. egg production traits, i.e., HDEP, feed efficiency, pullet and hen BW, mortality, and water use.
2. Characterize supply chain GHG, acidifying and eutrophying emissions, and energy demand for U.S. egg industry in both periods.
3. Quantify environmental footprint progress arising from technological advancements over the past 50 years.

Production Systems Compared

1960 Egg Production *vs.* 2010 Egg Production



Source: "*Keeping Chickens in Cages*" (by Hartman)

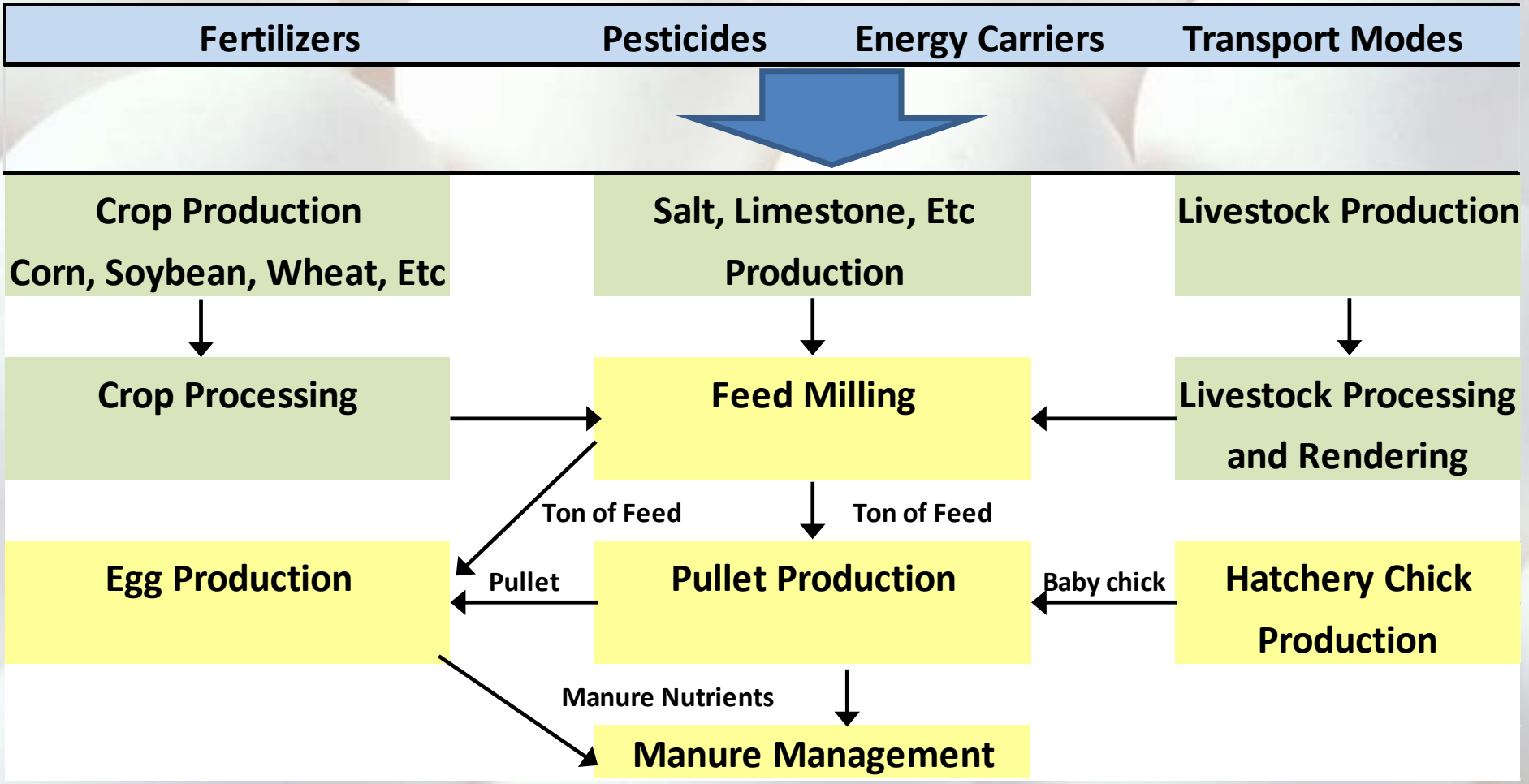
Environmental Footprint Indicators

- **Global Warming Potential (GWP):** a relative measure of heat trapped by a GHG as compared to CO_2 in the atmosphere, expressed in CO_2-eq.
- **Acidifying emissions (acidification):** Emissions (e.g., NO_x, SO_2, NH_3) or processes that cause decreased pH in ecological systems (soil/water), in SO_2-eq.
- **Eutrophying emissions (eutrophication)**: Introduction of artificial or natural substances, such as nitrates and phosphates, to aquatic systems (e.g., hypoxia – causing increased growth of algae), in PO_4-eq.
- **Cumulative Energy Demand (CED)**: life-cycle energy needs for production of a good or service, in MJ

Methodology:
Life Cycle Analysis (LCA) Protocols

- Life-cycle environmental impacts calculated using ISO-compliant LCA methodology and internationally-endorsed methods.
- Cradle-to-facility gate system boundaries (i.e., all direct and indirect supply chain inputs and emissions).
- Impact results examined to identify supply chain “hot spots” and opportunities for footprint mitigation.

Methodology – LCA Elements



Methodology – Input Data to Models

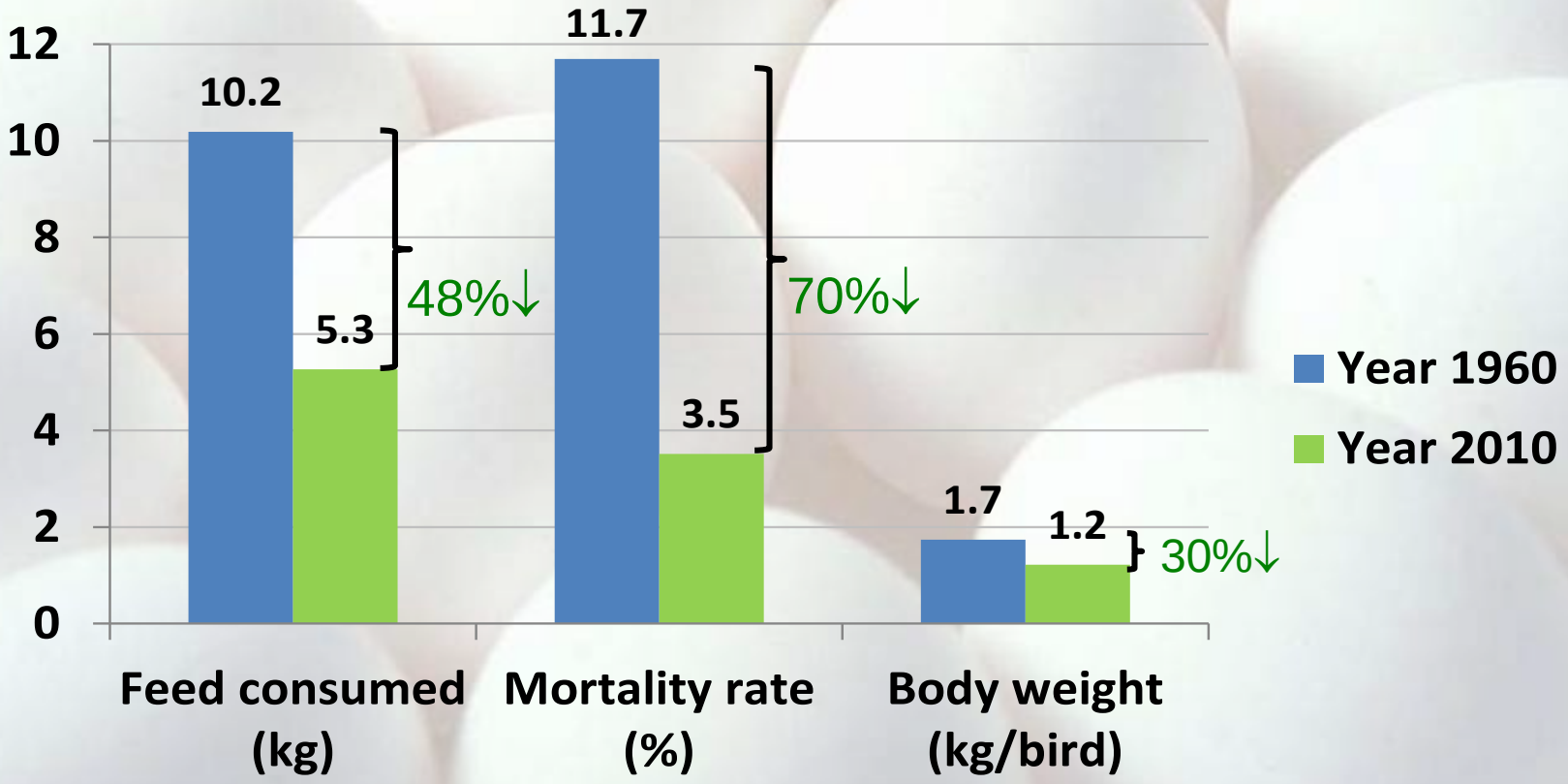
- Data for 1960 models collected from books, publications, and communication with industry and academic experts.
- USDA NASS publications, University extension pubs, IPCC reference, & peer-reviewed articles.
- Data for 2010 models collected via anonymous surveys with egg companies.
  - 57.1 million pullets
  - 92.5 million laying hens

Methodology – Data Collected

1) Production performance: hen-day egg production, feed use, egg weight, mortality rate, feed efficiency, BW of pullets at transfer to laying house, etc.
2) Manure production, composition and use
3) Feedstuffs production
4) Fertilizer production
5) Energy use: gasoline, diesel, electricity
6) Water use
7) Transportation: distance and modes
8) Other materials used (plastic, paper, etc.)

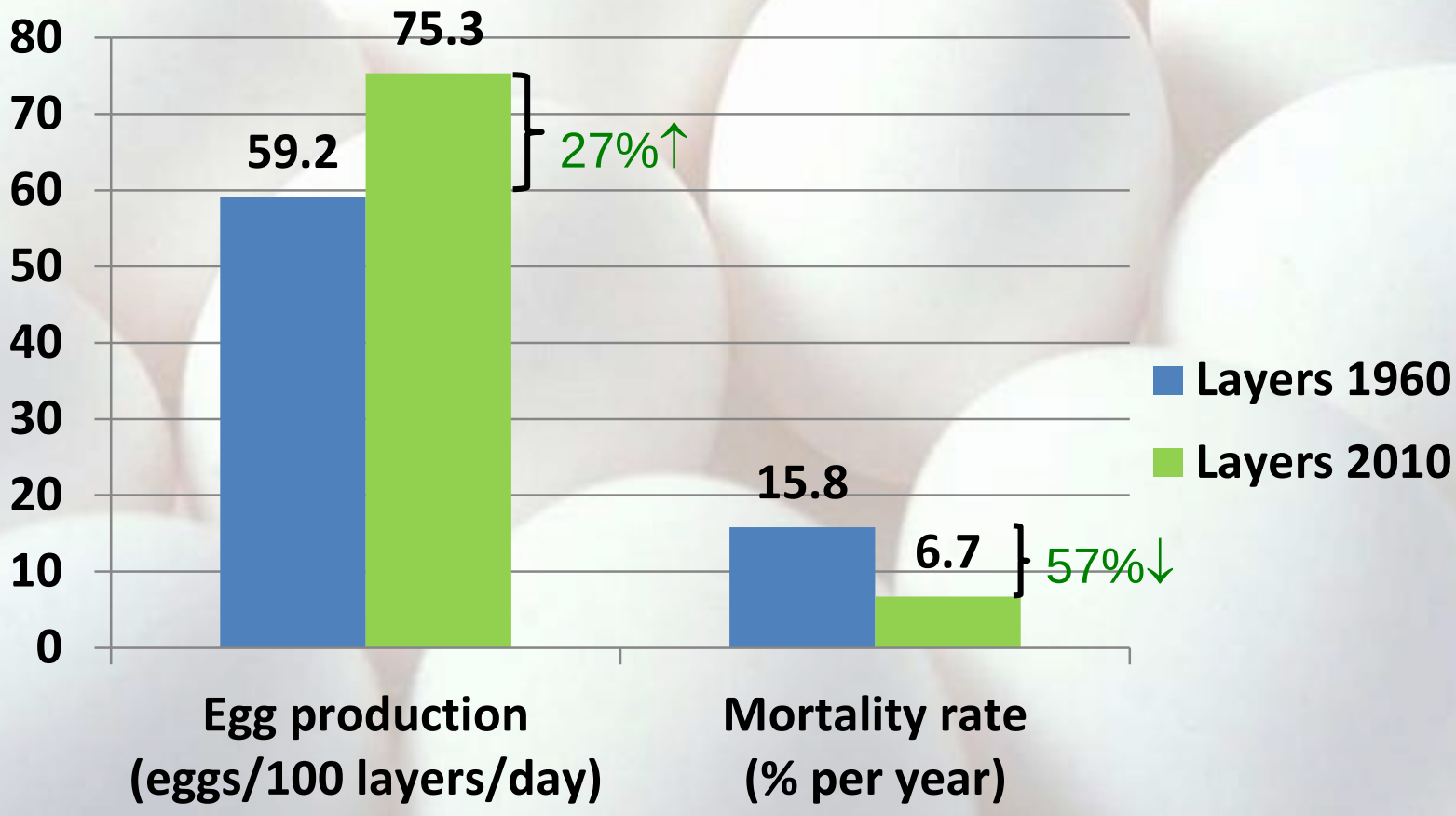
Key Findings of 50-Yr Study

Pullet Production: 2010 *vs.* 1960



Key Findings of 50-Yr Study

Layer/Egg Production: 2010 *vs.* 1960



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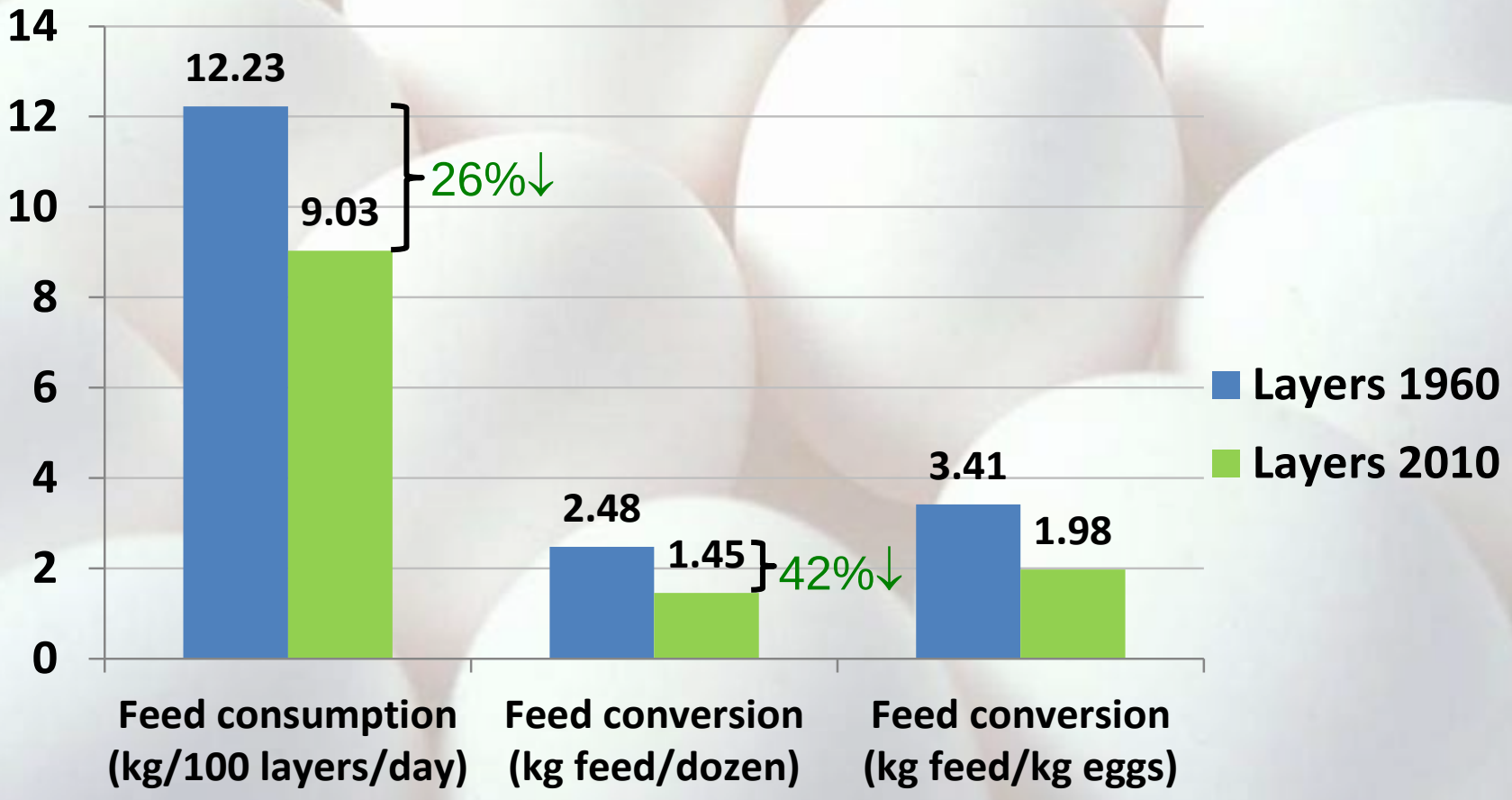
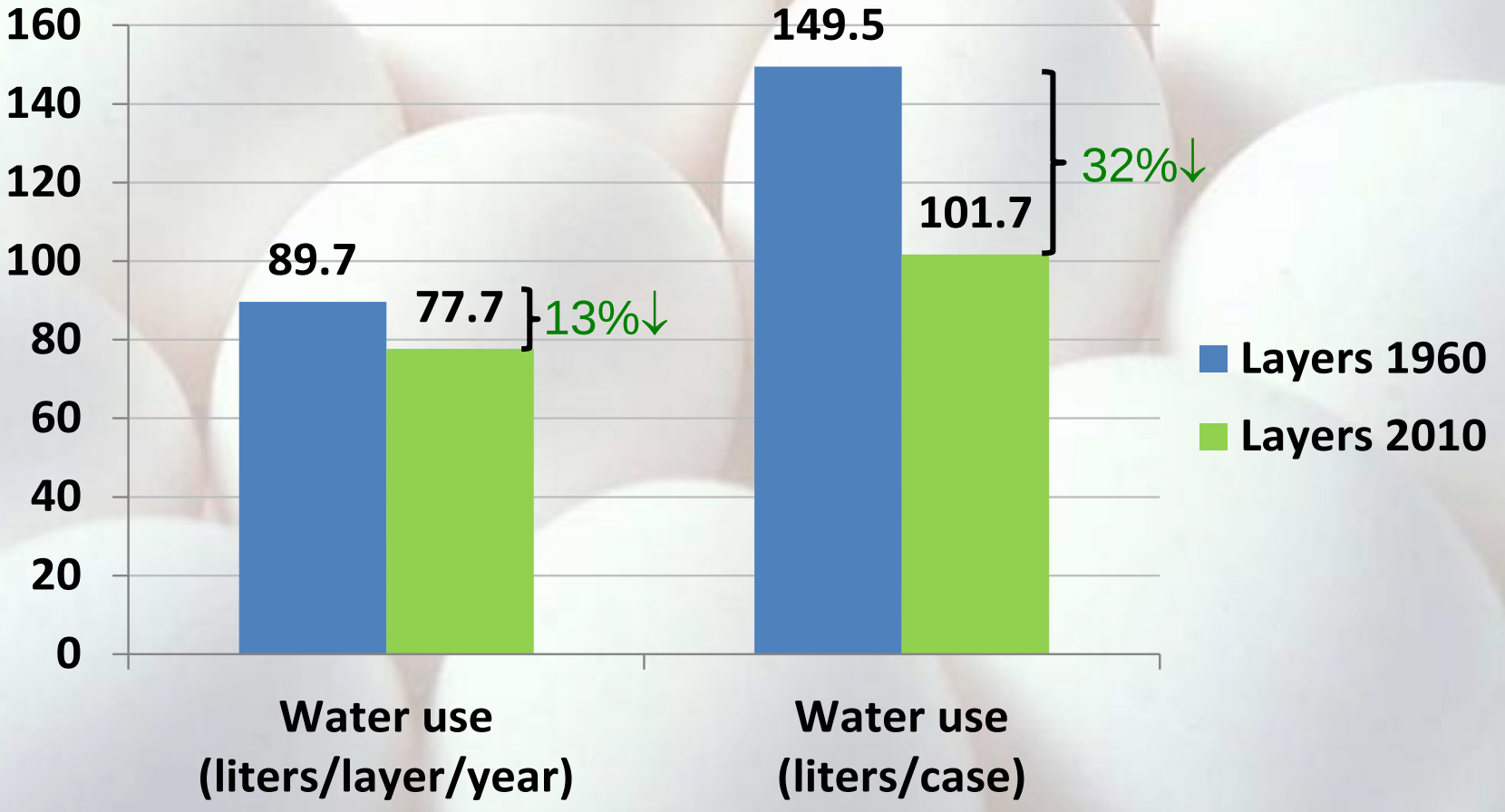


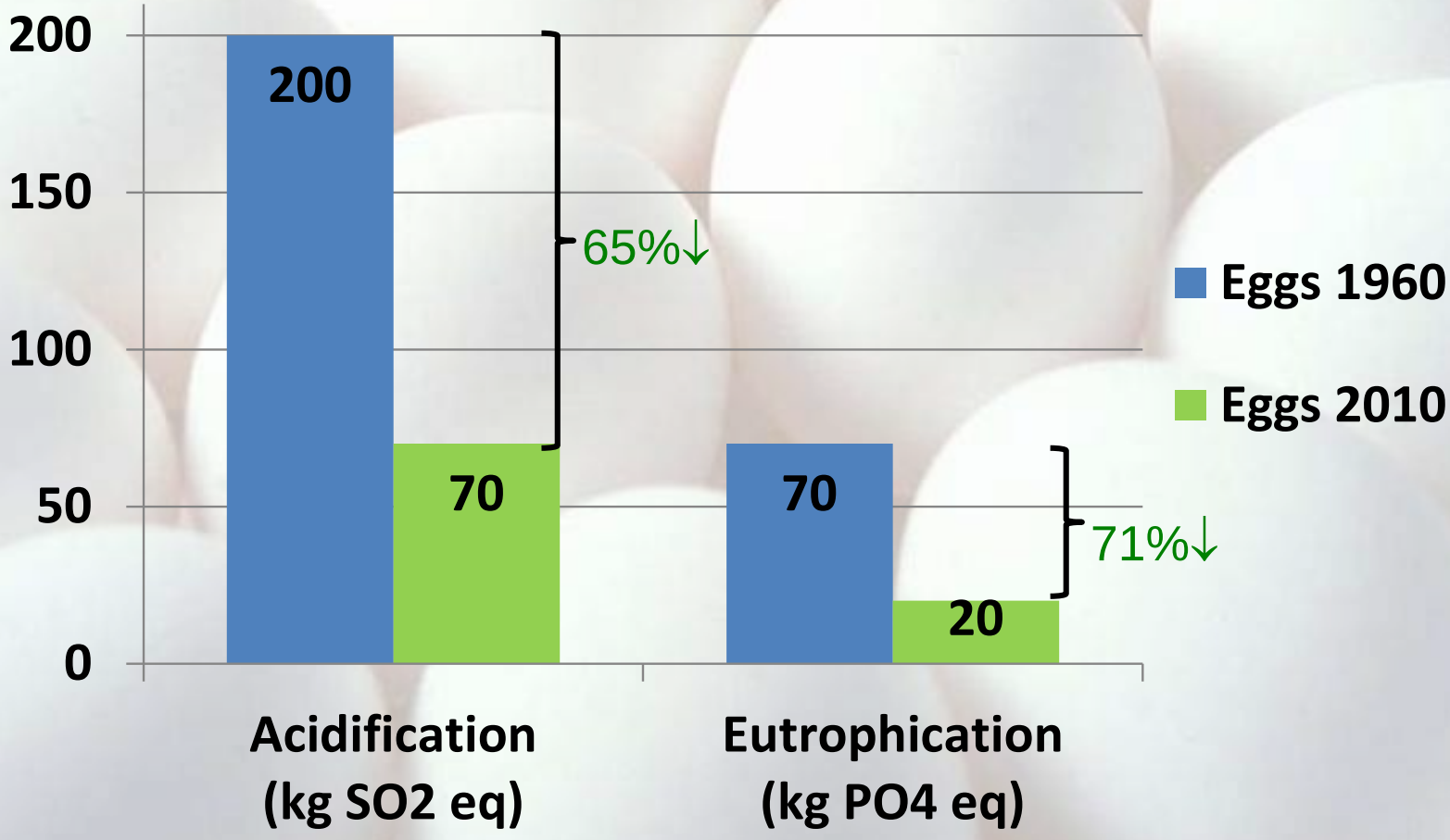
Key Findings of 50-Yr Study

Layer/Egg Production: 2010 vs. 1960



Key Findings of 50-Yr Study

Footprint per Tonne of Egg Production: 2010 *vs.* 1960



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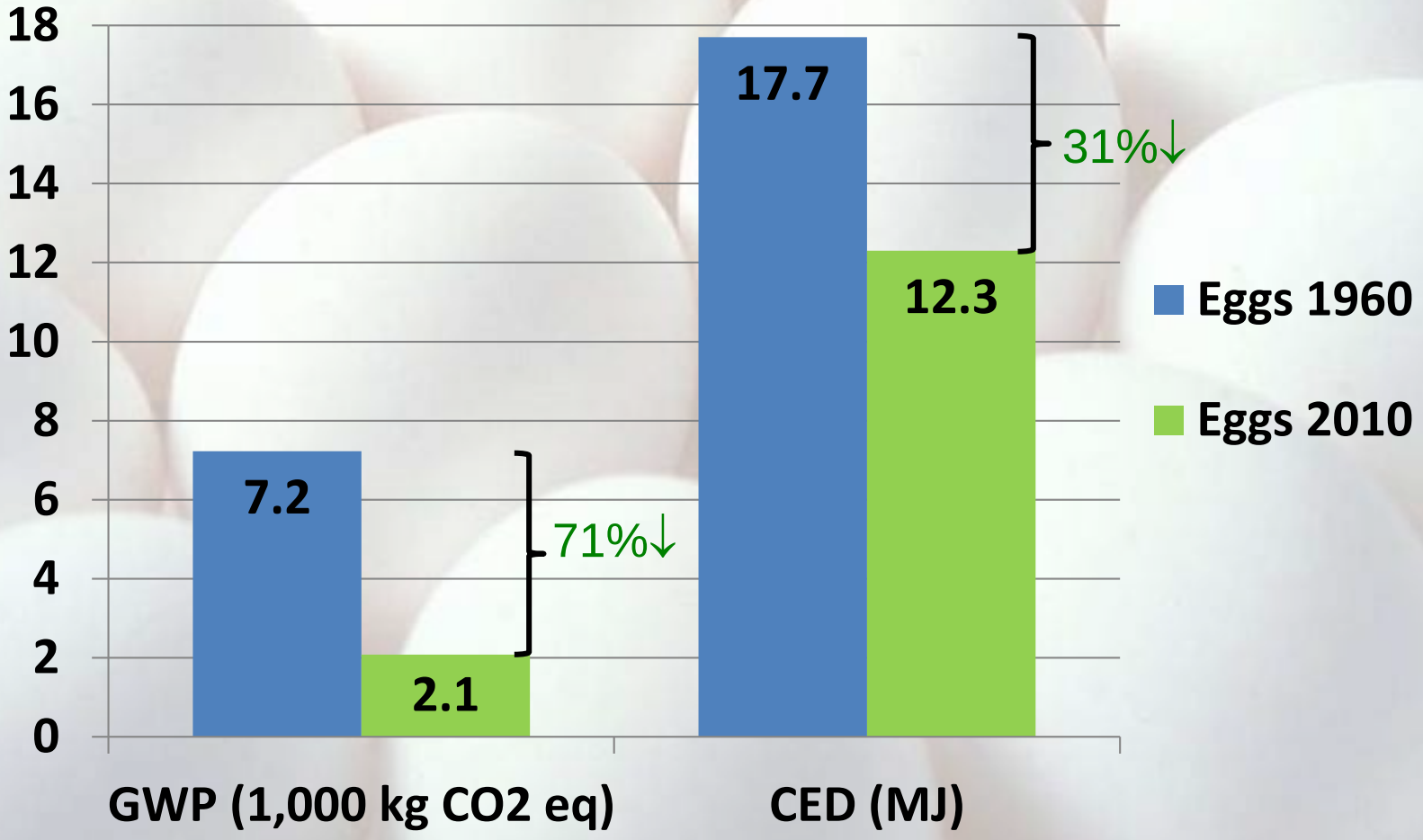
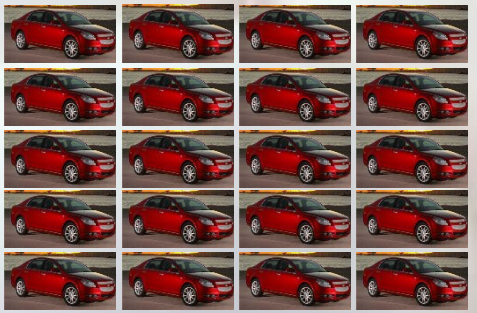


Key Findings of 50-Yr Study

- ✓ Environmental footprints of GHG, acidification and eutrophication emissions per kg egg output in 2010 are *one-third or less* of those in 1960.

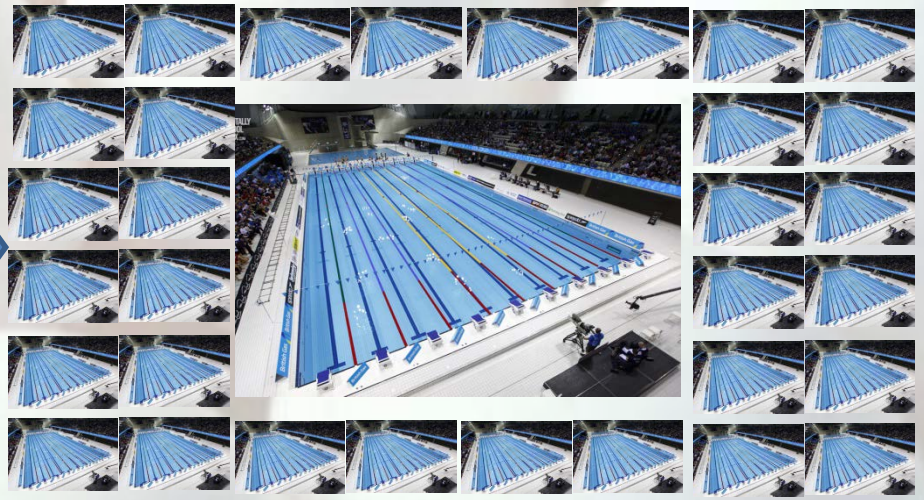
The reductions are equivalent to:

5.2 million cars off the road (25 million less metric ton CO_2-e)	Closure of ~59 U.S. coal plants (606,840 less metric ton SO_2)	100 million 50-lb bags (10-10-10) of lawn fertilizer (233,400 less metric ton PO_4)
		

Key Findings of 50-Yr Study

- ✓ Compared to 1960 hens, 2010 hens have
  - 32% lower water use, equivalent to annual water savings of

~9.3 million m^3 or ~2.5 billion gallons per year

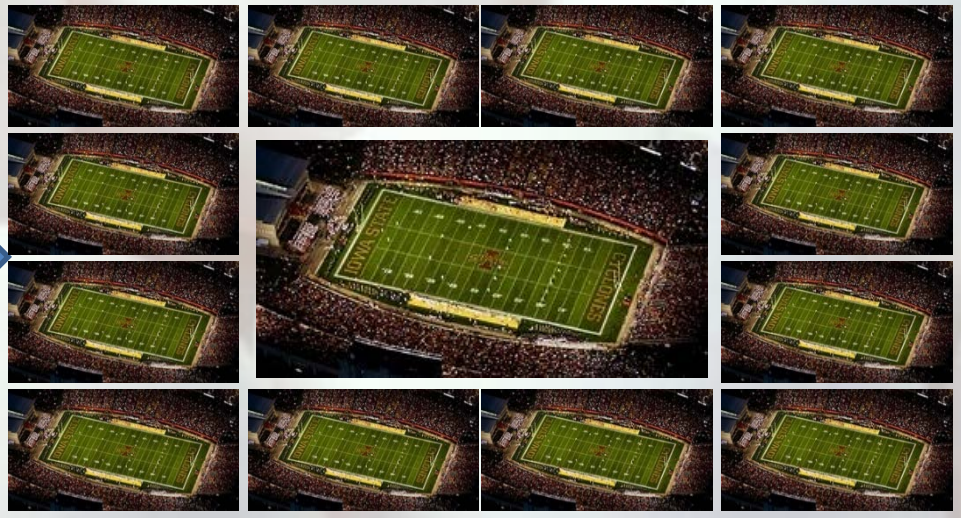


~ 3,700 Olympic swimming pools

Key Findings of 50-Yr Study

- ✓ Additional resources needed using 1960 technology to produce eggs for 2010:
  - 27% (78 million) more hens
  - 72% (1.3 million acre) more land for corn
  - 72% (1.8 million acre) more land for soybean

3.1 million acres or 1.25 million hectares of land



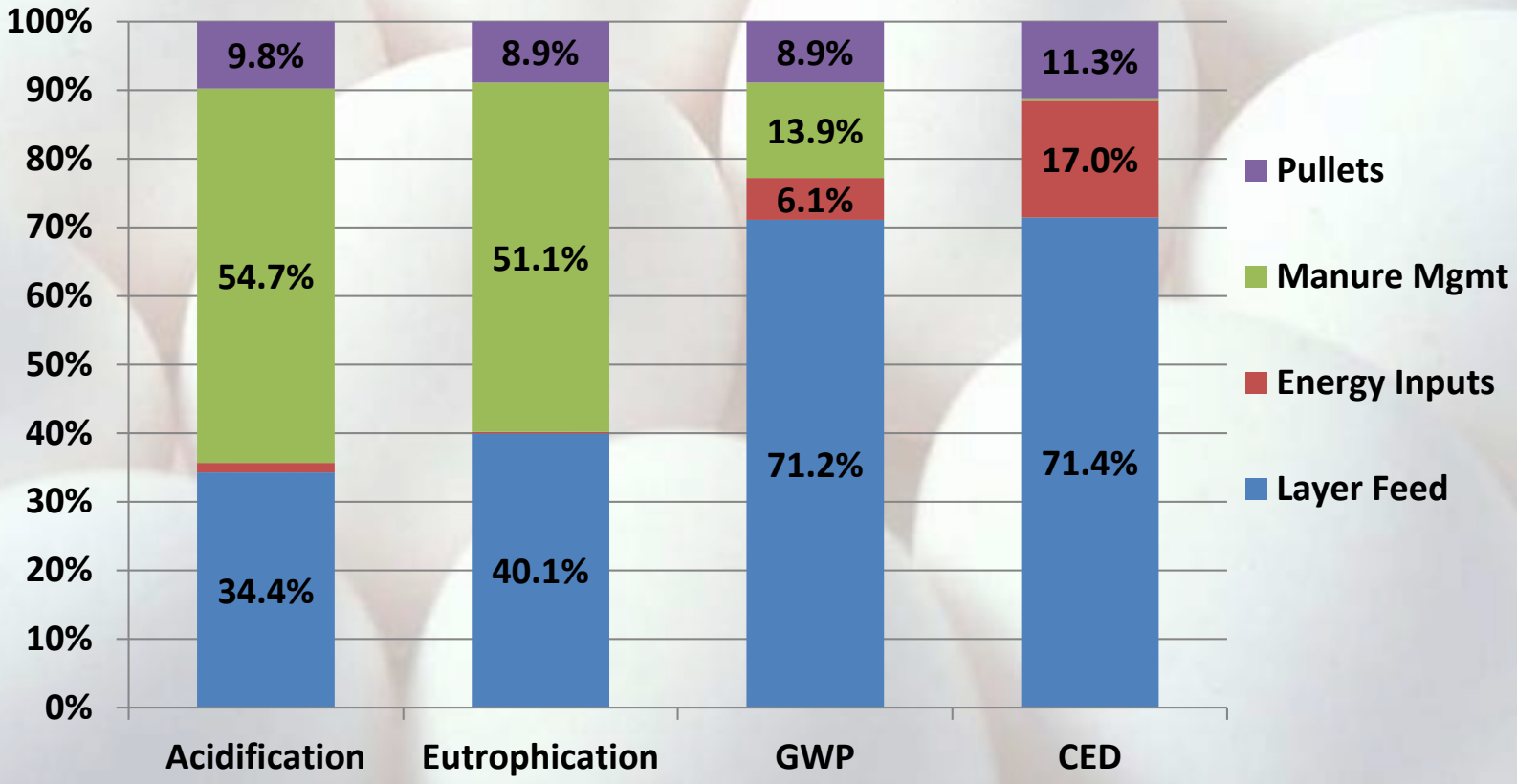
2.3 million football fields

Key Findings of 50-Yr Study

- ✓ While supplying 30% more eggs in 2010, the total environmental footprints are 54% to 63% lower than in 1960 except for CED that is 10% less.
- ✓ Manure management and feed efficiency are the primary “hot spots” for reducing footprint.

Key Findings of 50-Yr Study

Relative Footprint Contributions of Egg Production Components

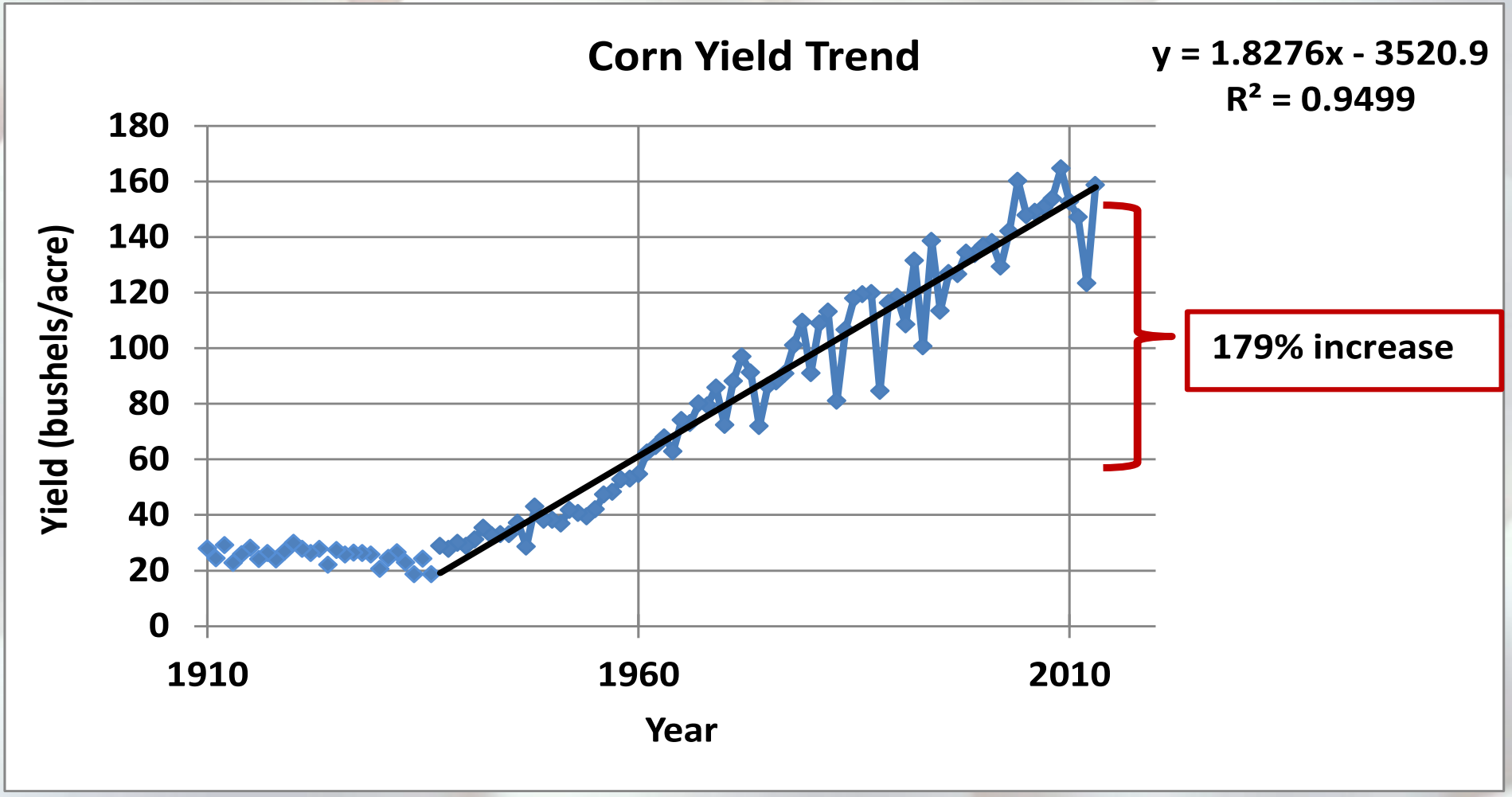


II. Drivers Responsible for the Observed Changes

Drivers for the Resultant Changes

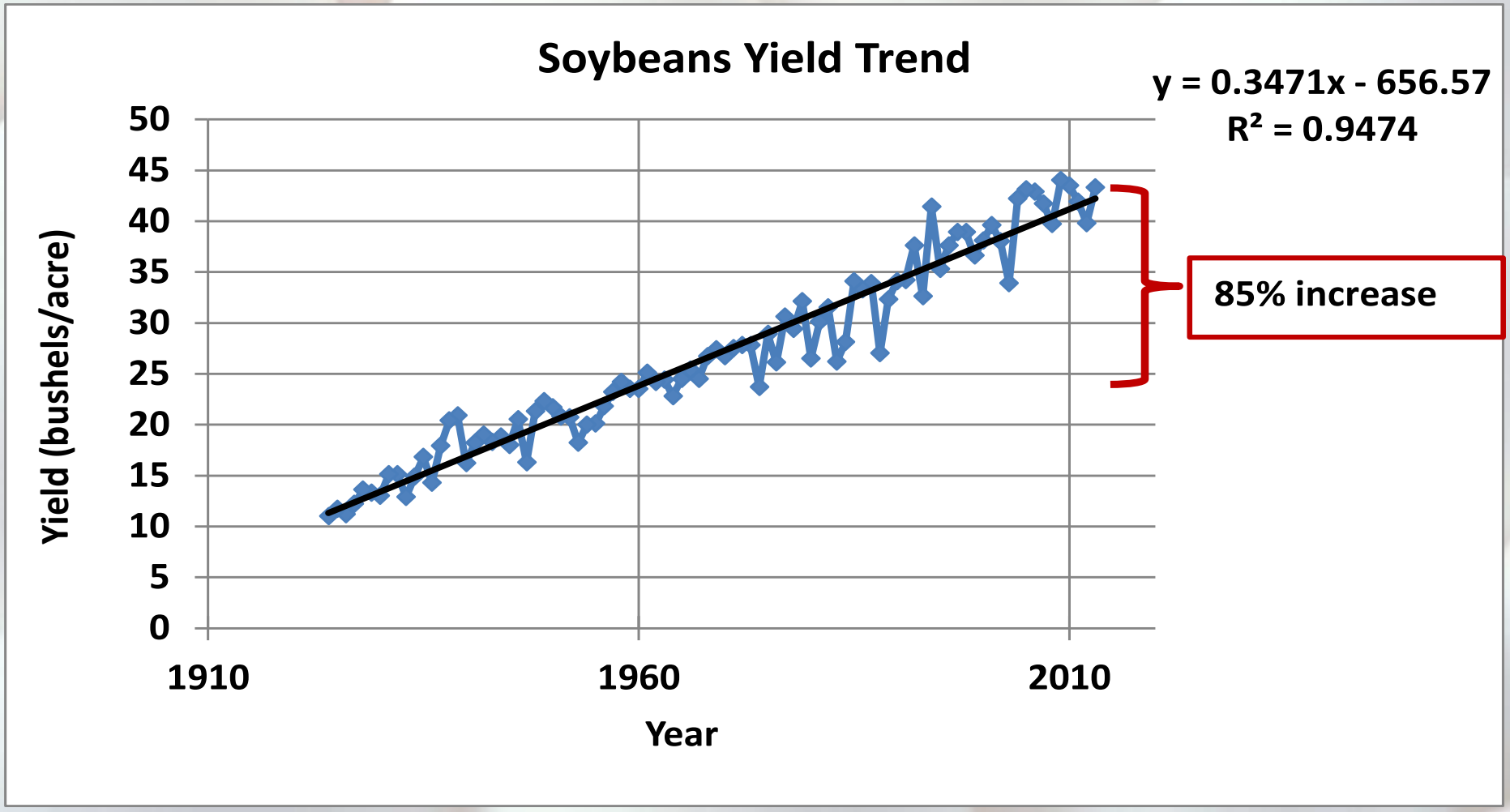
1. Background systems
   - crop yields, energy carriers, fertilizer, transport modes, etc.
2. Feed composition
3. Animal performance

Changes in Background System:
Corn Yield



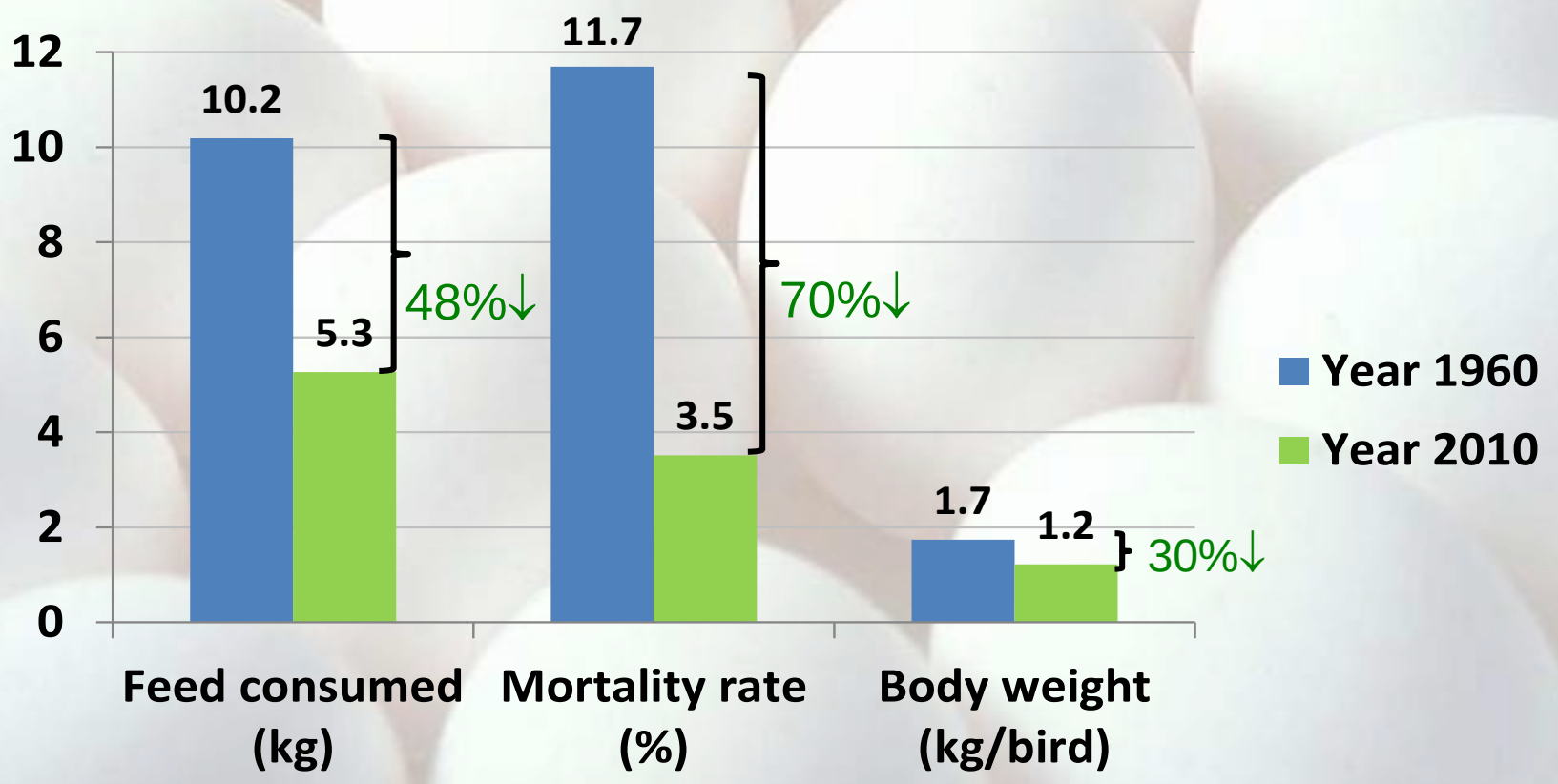
Source: USDA NASS

Changes in Background System: *Soybean Yield*

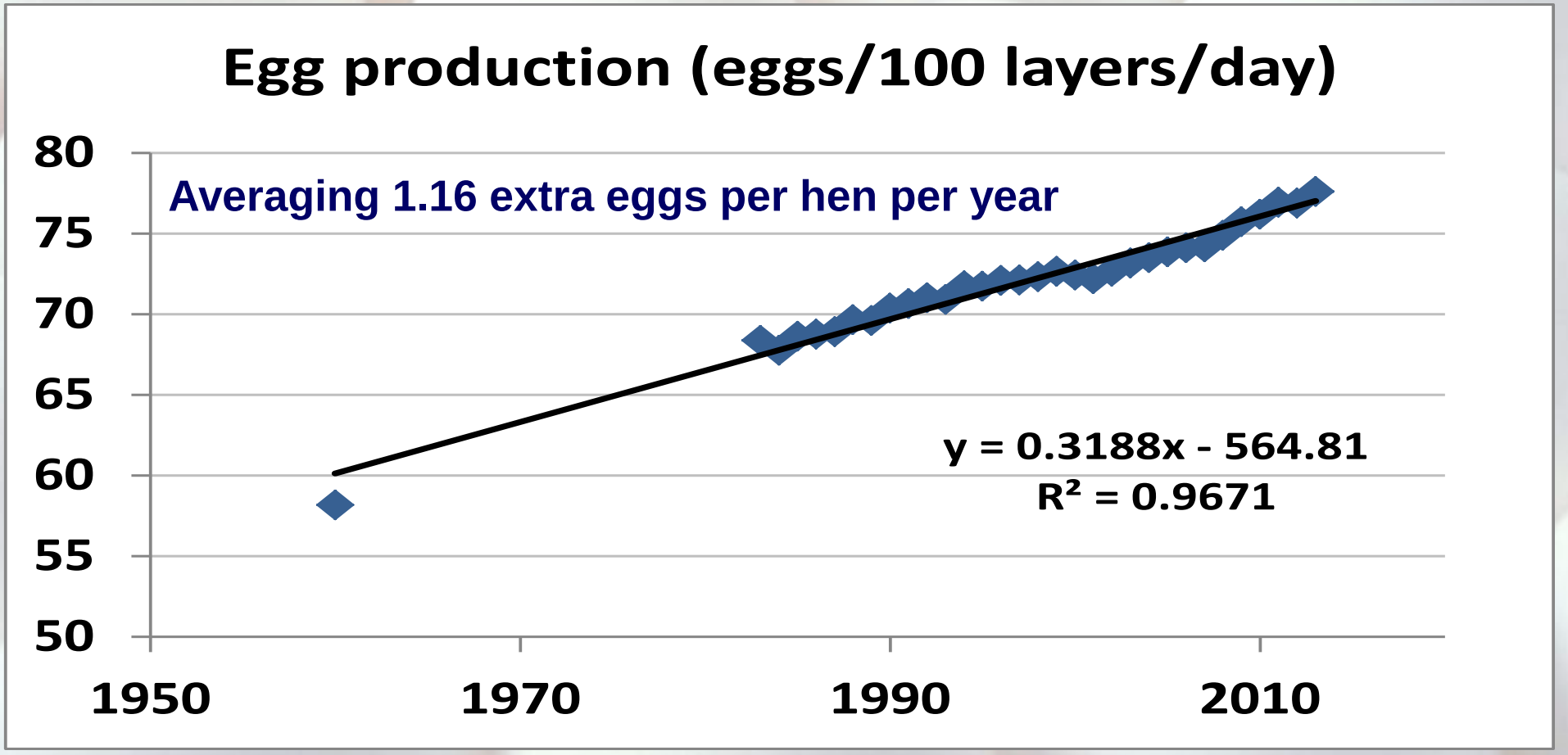


Source: USDA NASS

Changes in Animal Performance: *Pullets*

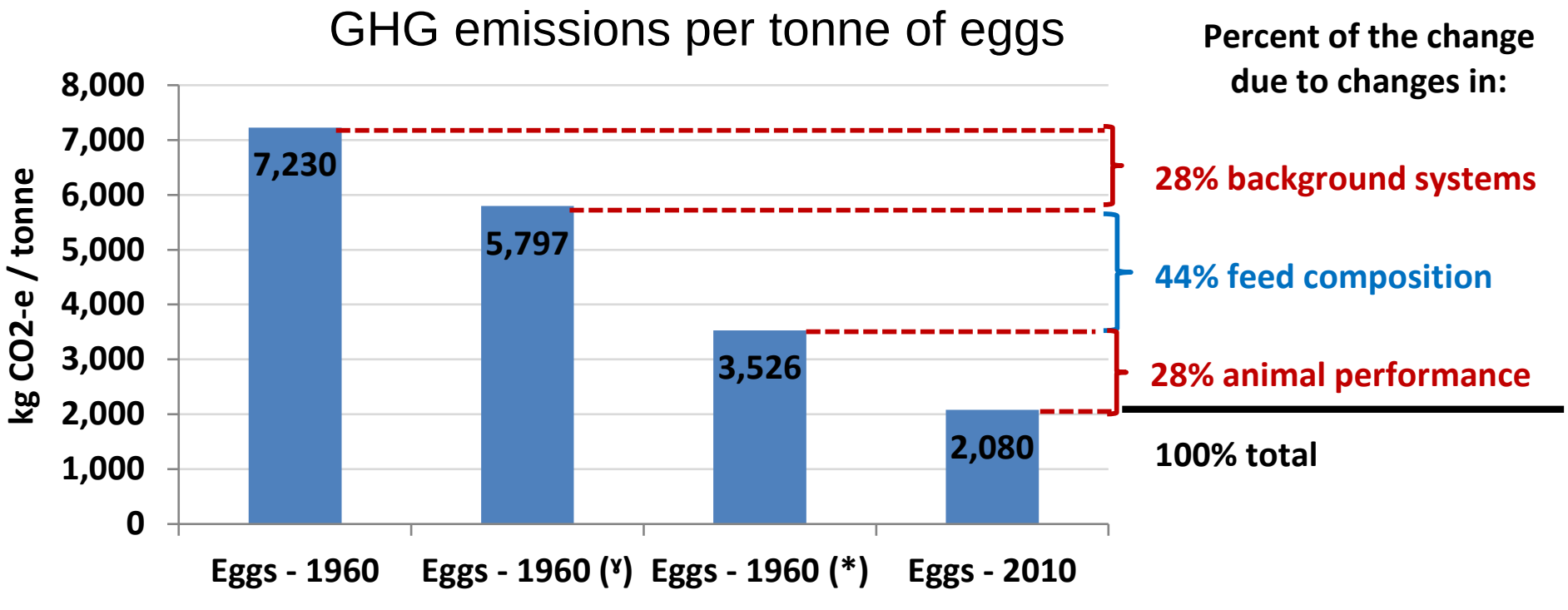


Changes in Animal Performance:
Hen Productivity



A hen in 2010 produces 58 extra eggs per year than her counterpart in 1960!

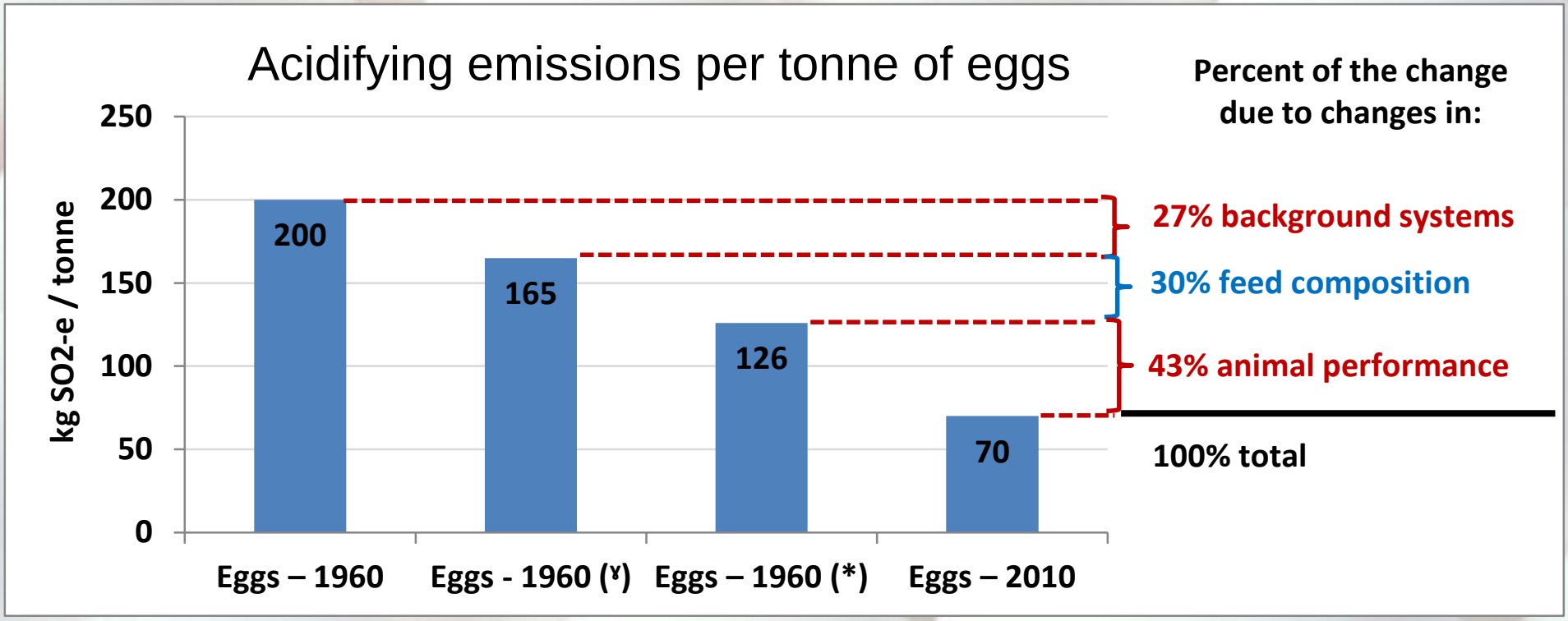
Partitioning of Drivers for Resultant Changes in *GHG Emissions*



(ɣ) Same background system data (i.e., crop yields, energy carriers, fertilizers, transport modes, etc.) as in 2010 model.

(*) Same feed composition and background system data as in 2010 model (i.e., only differences in feed conversion, mortalities, emissions from manure management, etc. are considered).

Partitioning of Drivers for Resultant Changes in *Acidifying Emissions*



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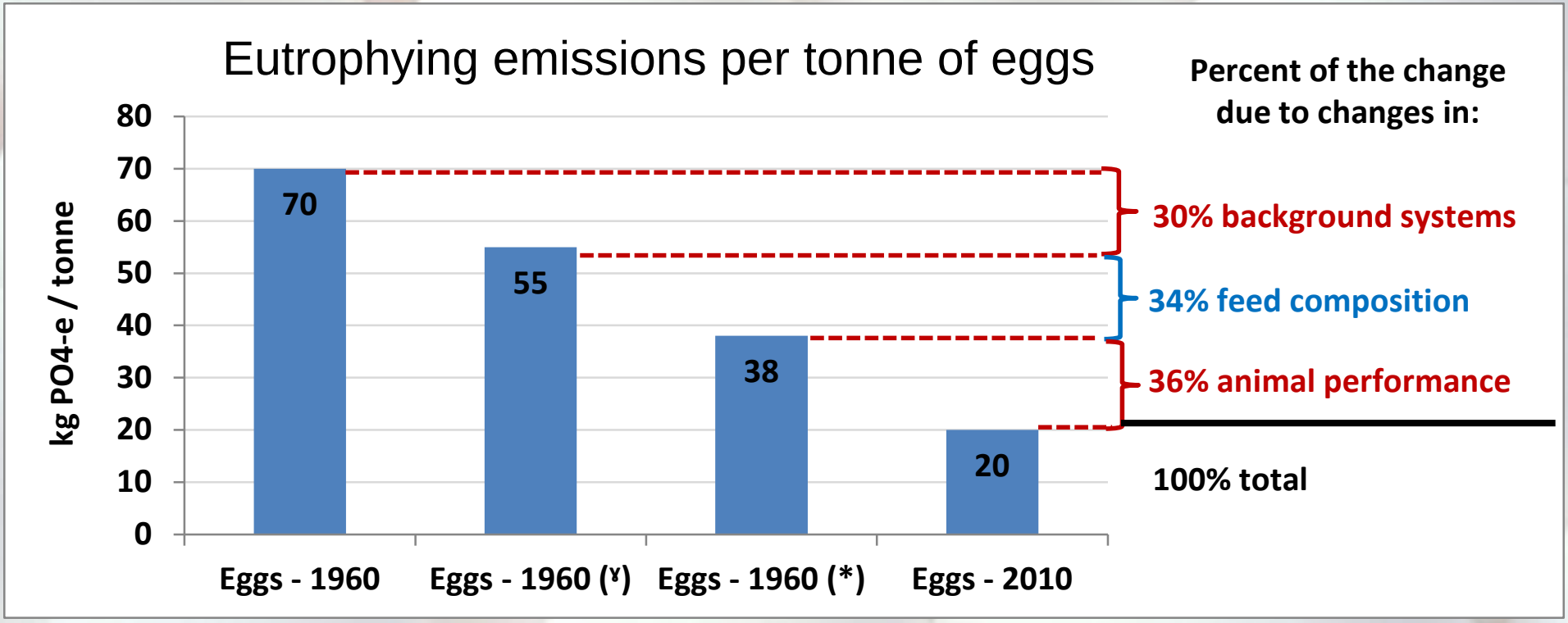
Partitioning of Drivers for Resultant Changes in *Eutrophying Emissions*



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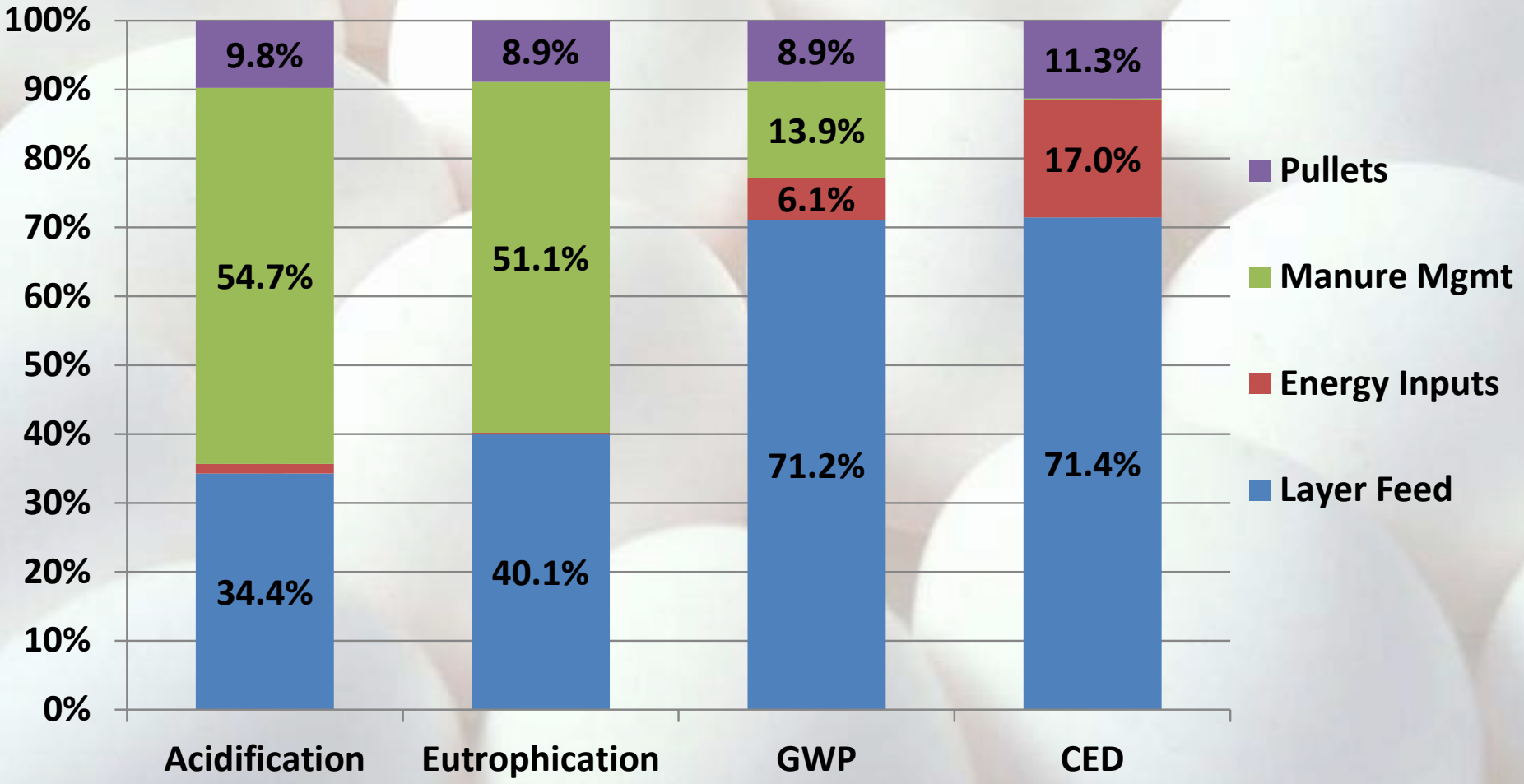
(*) Same feed composition and background system data as in 2010 model (i.e., only differences in feed conversion, mortalities, emissions from manure management, etc. are considered).

III. Opportunities for Further Improvements

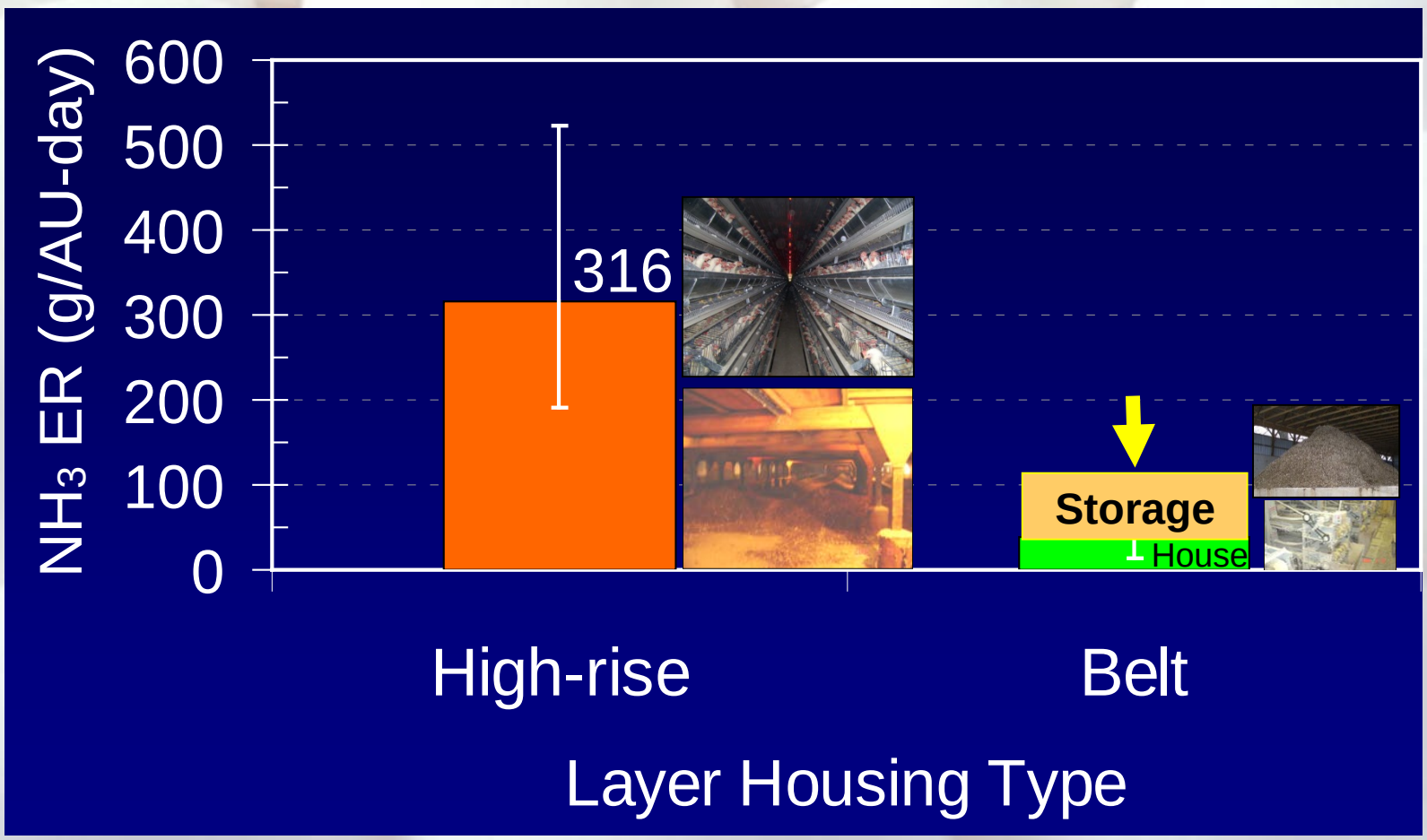
Relative Contributions of EGG Production Environmental Footprint



- Manure management and feed efficiency are the primary “hot spots”.

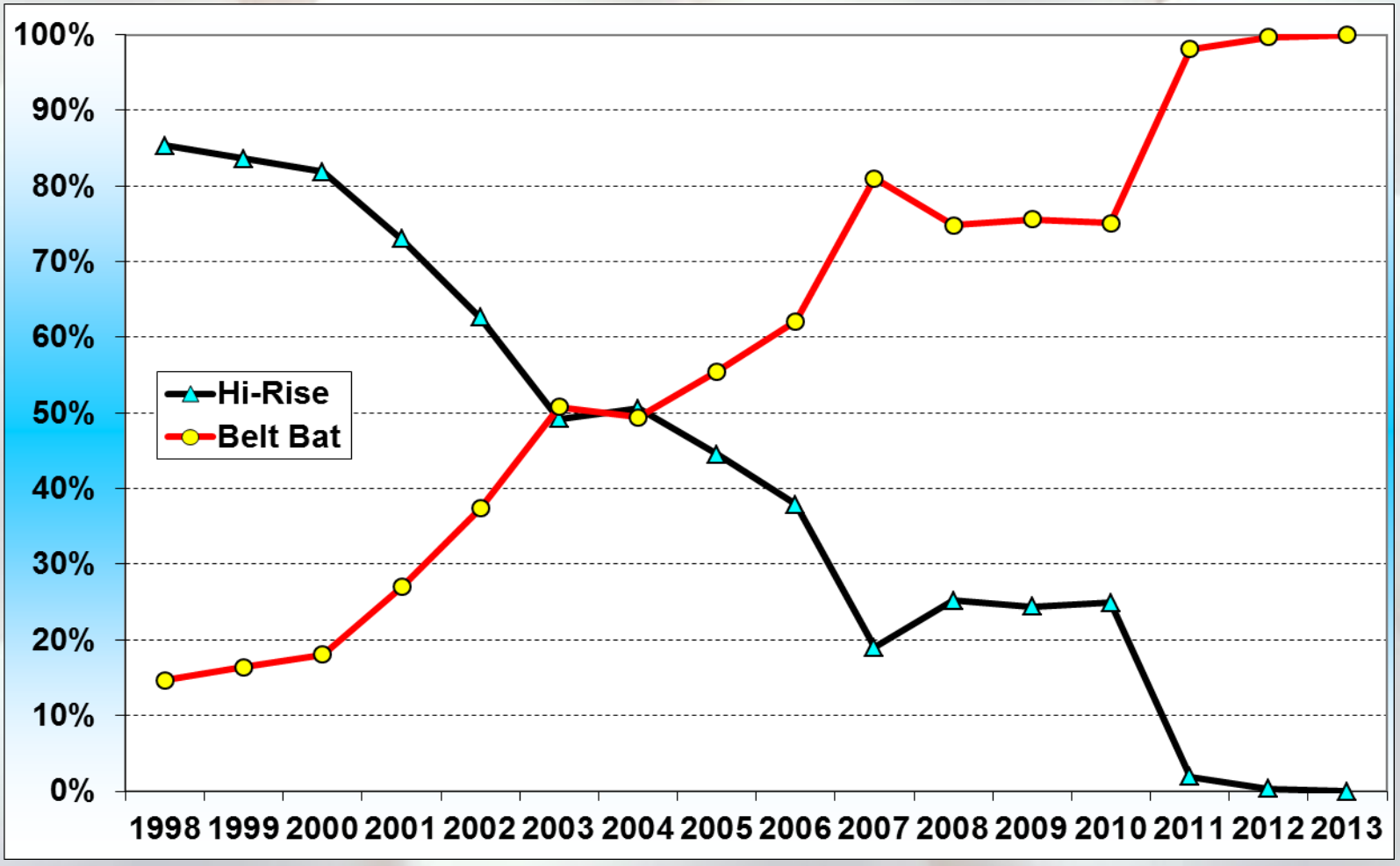
Further Improvement:

Housing & Manure Management – NH_3 Emissions of high-rise vs. manure-belt



AU = animal unit = 500 kg body weight

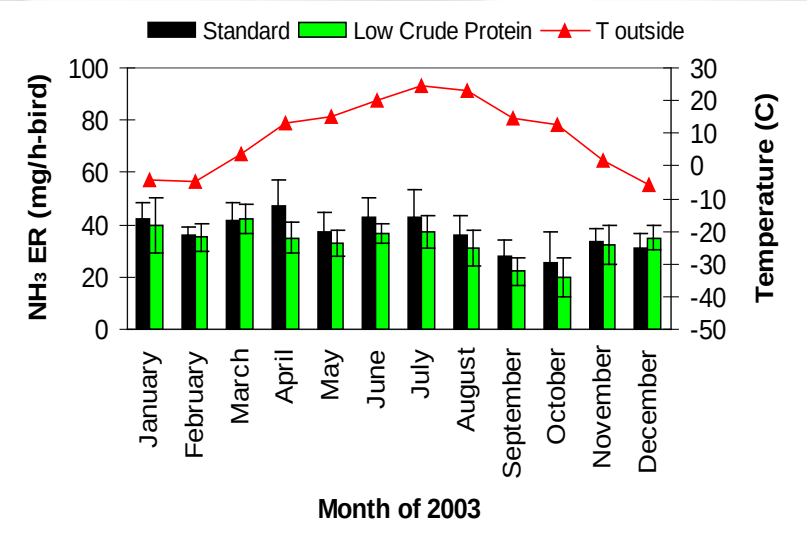
Further Improvement:
U.S. Trend in Hen House Construction

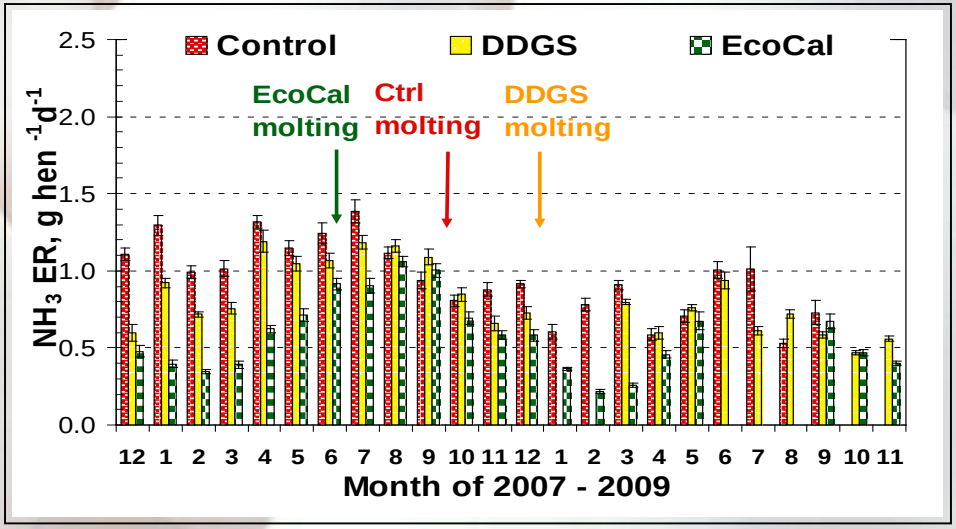


Courtesy of Tom Lippi & Rick VanPuffelen, CTB

Potential Further Improvement:
Dietary Modification

➢ 1% lower CP → 11% reduction in NH_3 emission





NH_3 ER (g/hen-d)	
Standard Diet	LP Diet
0.90 (0.24-1.58)	0.80 (0.19-1.37)

Liang et al. (2005)

NH_3 ER (g/hen-d)		
Control	DDGS	EcoCal
0.96 (0.05)	0.82 (0.05)	0.58 (0.05)
% ↓	14 (5)	39 (5)

Li et al. (2012)

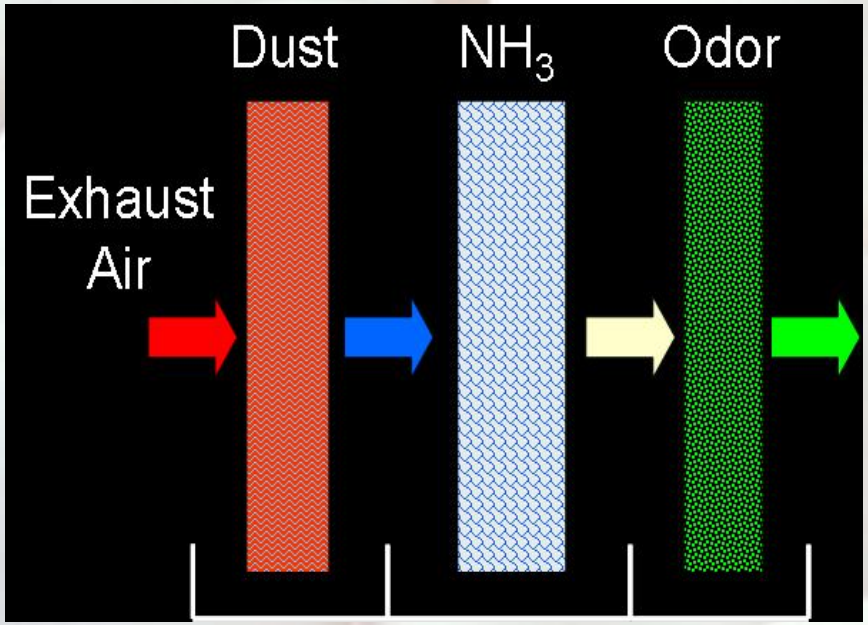
Potential Improvement:
Treating Exhaust Air – Vegetative Buffer

- PM reduction: 49±27% (33 d)
- NH_3 reduction: 46±31% (29 d)
- Odor reduction: negligible

Patterson (2013)

Malone et al., (2006)

Potential Improvement:
Treatment of Exhaust Air – Wet Scrubber



3-stage scrubber :

- Capital cost: $47-$72/pig
- Operation cost: $15-$19/yr

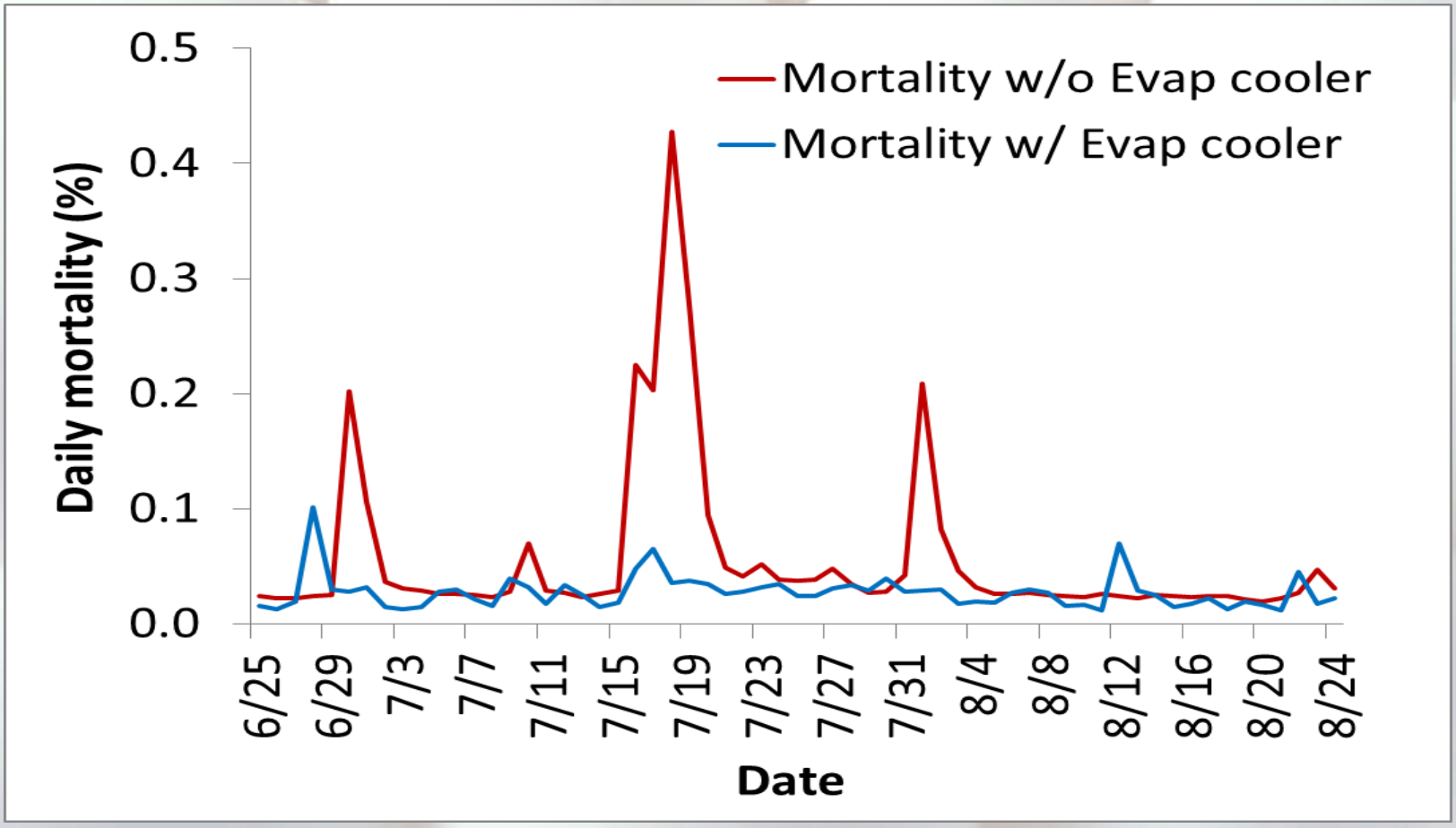
Further Improvement:
Better Housing Environment Control

- Evaporative cooling pads at air inlet
- New construction

- High pressure fogging at air inlet (~1,000 psi or ~7,000 kPa)
- Retrofitting

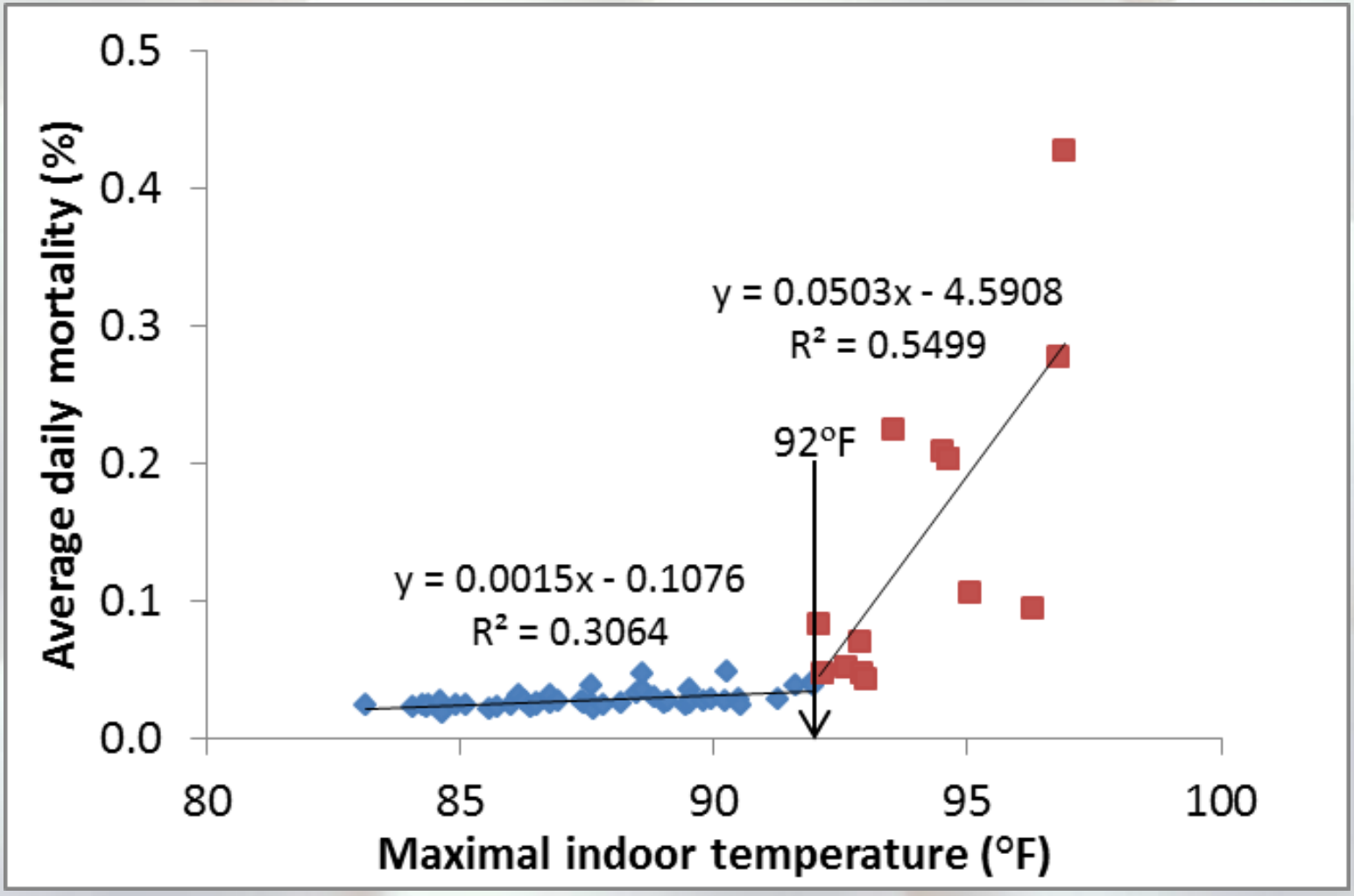
- Enhance cooling efficiency through tunnel ventilation

Further Improvement:
Better Environmental Control – Impact of Pad-Fan Cooling on Laying-Hen Mortality



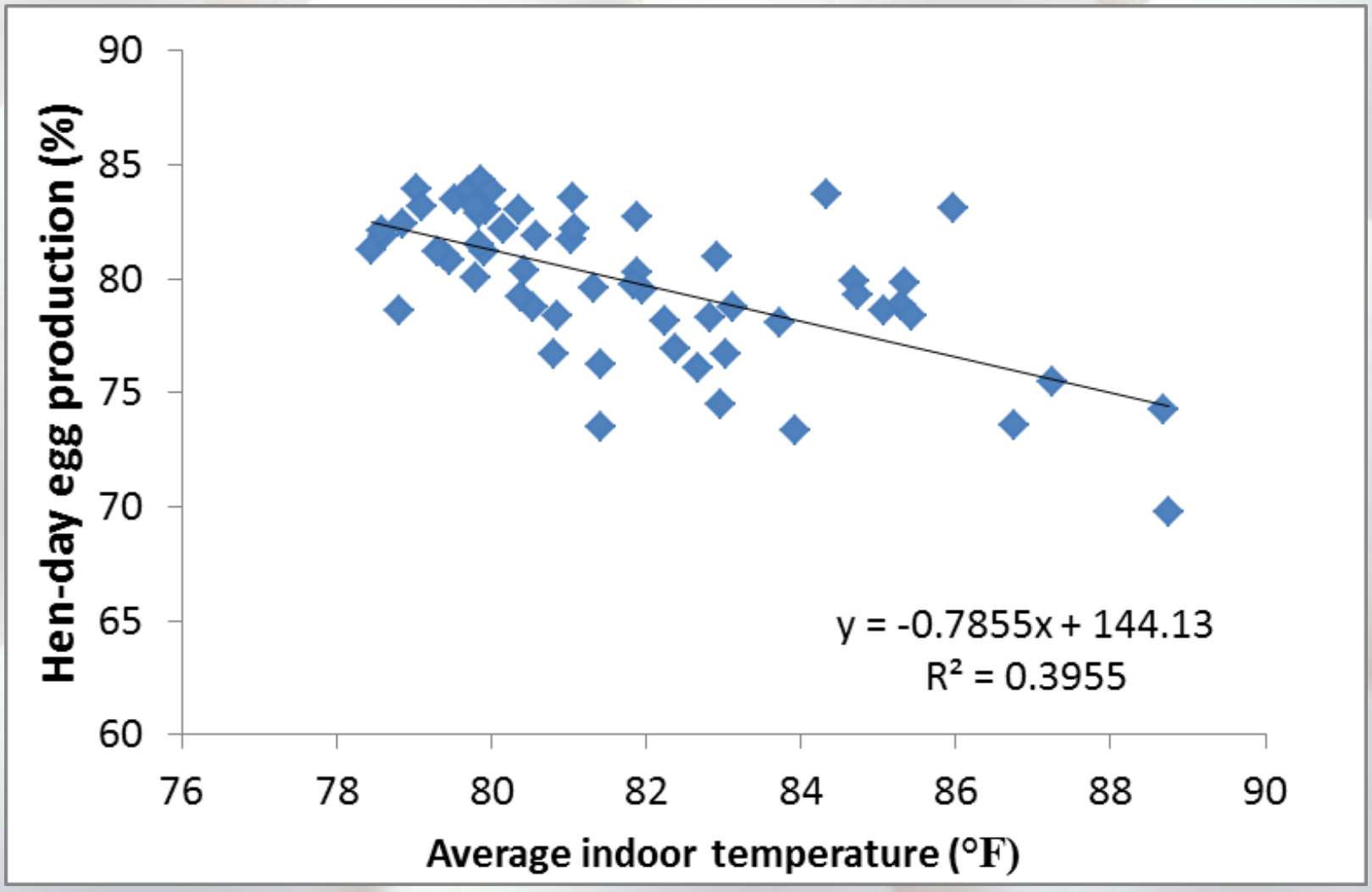
Xin, 2013 (unpublished data)

Hen Mortality *vs.* Max Indoor Temp



Xin, 2013 (unpublished data)

Hen-Day Egg *vs.* Indoor Temperature



Xin, 2013 (unpublished data)

Summary

- ✓ Egg production in the United States has advanced dramatically over past 50 years.
  - Environmental footprints for 1 kg egg output in 2010 are 1/3 or less of those in 1960.
- ✓ The reductions in environmental footprint are attributable to advancements in:
  - Background systems (27% – 30%)
  - Feed composition (30% – 44%)
  - Animal performance (28% – 43%)
- ✓ Feed efficiency and manure management are the primary areas for further improvements.

Acknowledgements

- American Egg Board, United Egg Allied, U.S. Poultry and Egg Association, and Egg Industry Center for funding the 50-yr Study.
- Participating U.S. egg companies for their cooperation in providing the essential data.
- UEP staff for their support and assistance with the industry survey.
- Mr. Don Bell and Dr. Jim Arthur for their insights about the 1960 egg production.

7th Egg Industry Issues Forum

April 20-21, 2016

Chicago, Illinois, USA

Advancing research and outreach for the egg industry worldwide.

Check EIC Website:
http://www.eggindustrycenter.org