Economic Analysis of Supplemental Deductible Coverage as Recommended in the USDA's 2007 Farm Bill

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Motivation

- Title X of the USDA's 2007 Farm Bill:

  "Allow farmers to purchase supplemental insurance that would cover all or part of their individual policy deductible in the event of a county or area wide loss."
- Similar to H.R. 721 The Risk Management Enhancement Act, sponsored by Neugebauer (R-TX) and others, including Mark Green (R-WI)
- Main Point: Policy makers are examining various types of supplemental coverage

Why Supplemental Coverage?

- Provide "Gap Coverage" to fill the "hole in the safety net", especially in high risk areas
- High risk areas = high premiums, and deductible still exceeds profit margin
- Supplemental coverage will increase effective coverage
  - Reduce need for disaster assistance
  - Lower premium for SDC than for APH with the same liability

Purpose of Presentation

- Describe Supplemental Deductible Coverage (SDC) as proposed in 2007 USDA Farm Bill
- Economic Analysis of SDC at farm level
  - Effect on Farmer Welfare (certainty equivalent)
  - Effect on Farmer Behavior (coverage level)

How Individual Crop Insurance (APH) Coverage Works

- Farmer chooses farm yield guarantee as proportion α_{aph} of expected yield μ_f
- Expected yield μ_f calculated as moving average of actual production history (APH)
- APH indemnities based on farmer yield

$$I_{aph} = P_{aph} \times \max\{\alpha_{aph}\mu_f - y_f, 0\}$$

How Areawide Crop Insurance (GRP) Coverage Works

- Choose county yield guarantee as proportion α_{grp} of expected county yield μ_c
- RMA sets GRP expected county yield μ_c
- GRP indemnities based on county yield

  $I_{grp} = MP_{grp} \times \max\{(\alpha_{grp}\mu_c - y_c)/(\alpha_{grp}\mu_c), 0\}$

  MP_{grp} = GRP maximum protection per acre

  $= 150\% \times P_{aph} \times \mu_c$
- Calculate county % loss from guarantee , then paid that percentage of liability MP_{grp}

Simple APH Example

- Farm mean μ_f = 100, choose 75% coverage (α_{aph} = 0.75), so APH yield guarantee = 75 bu/ac
- Deductible (bu/ac) = 100 – 75 = 25 bu/ac
- D_{aph} ($/ac) = P_{aph} x 25 bu/ac
- If actual harvest y_f = 60 bu/ac, then loss is max(75 – 60, 0) = 15 bu/ac and indemnity is P_{aph} x 15 bu/ac

Simple GRP Example

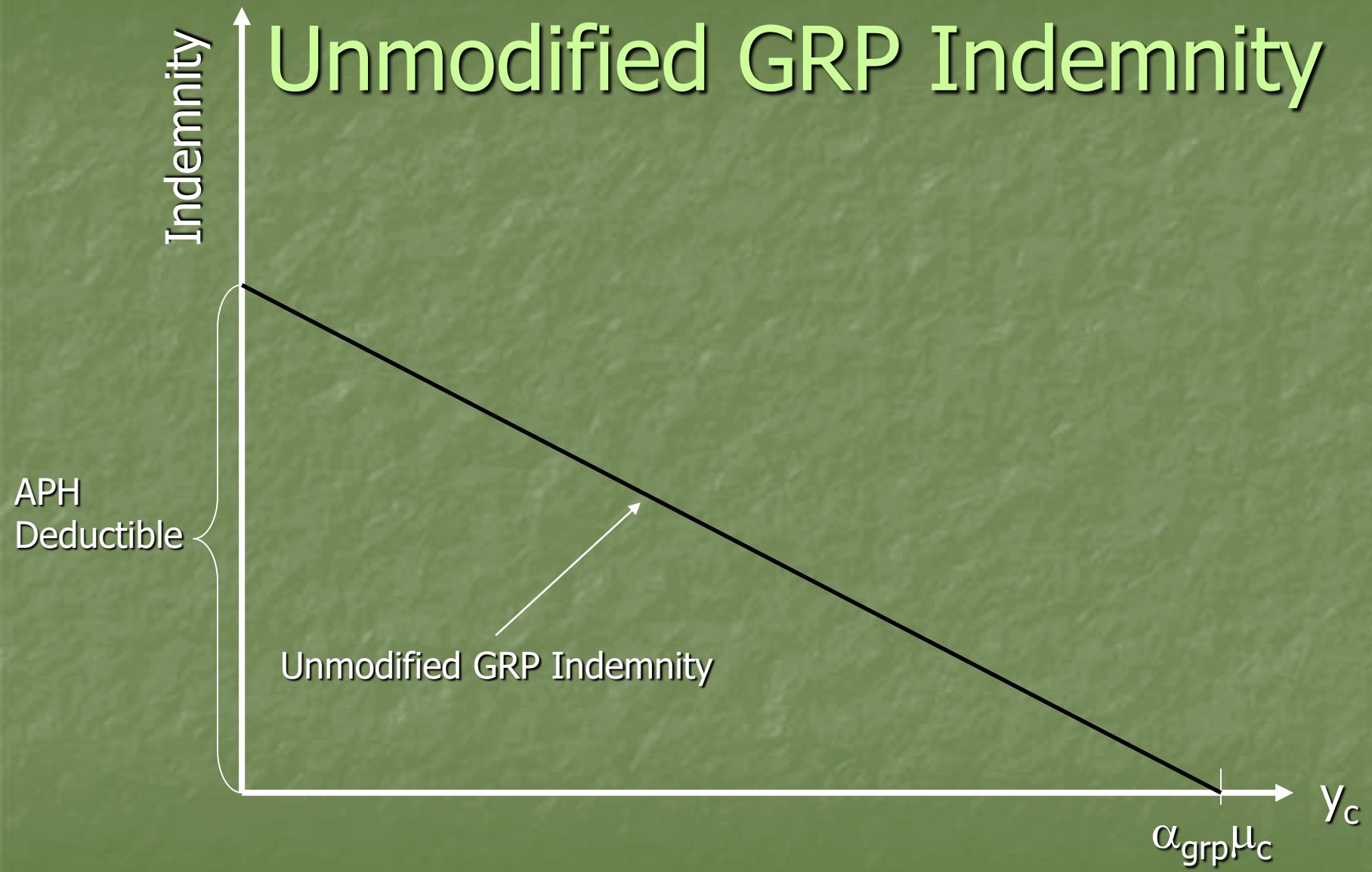
- County mean μ_c = 100, choose 90% coverage (α_{grp} = 0.90), so GRP yield guarantee = 90 bu/ac
- If actual county yield y_c = 80 bu/ac, then loss is max((90 – 80)/90, 0) = 11.1%
- Indemnity = MP_{grp} x 0.111, where

  MP_{grp} = 150% x P_{aph} x 100 bu/ac

How SDC would work

- Allow farmer with APH coverage to buy GRP coverage modified to have liability equal to APH deductible, so SDC indemnity is
- $I_{sdc} = I_{aph} + I_{mgrp}$
- $I_{mgrp} = D_{aph} \times \max\{(\alpha_{grp}\mu_c - y_c)/(\alpha_{grp}\mu_c), 0\}$
- I_{mgrp} = GRP indemnity, replacing maximum protection per acre MP_{grp} with APH deducible

Unmodified GRP Indemnity

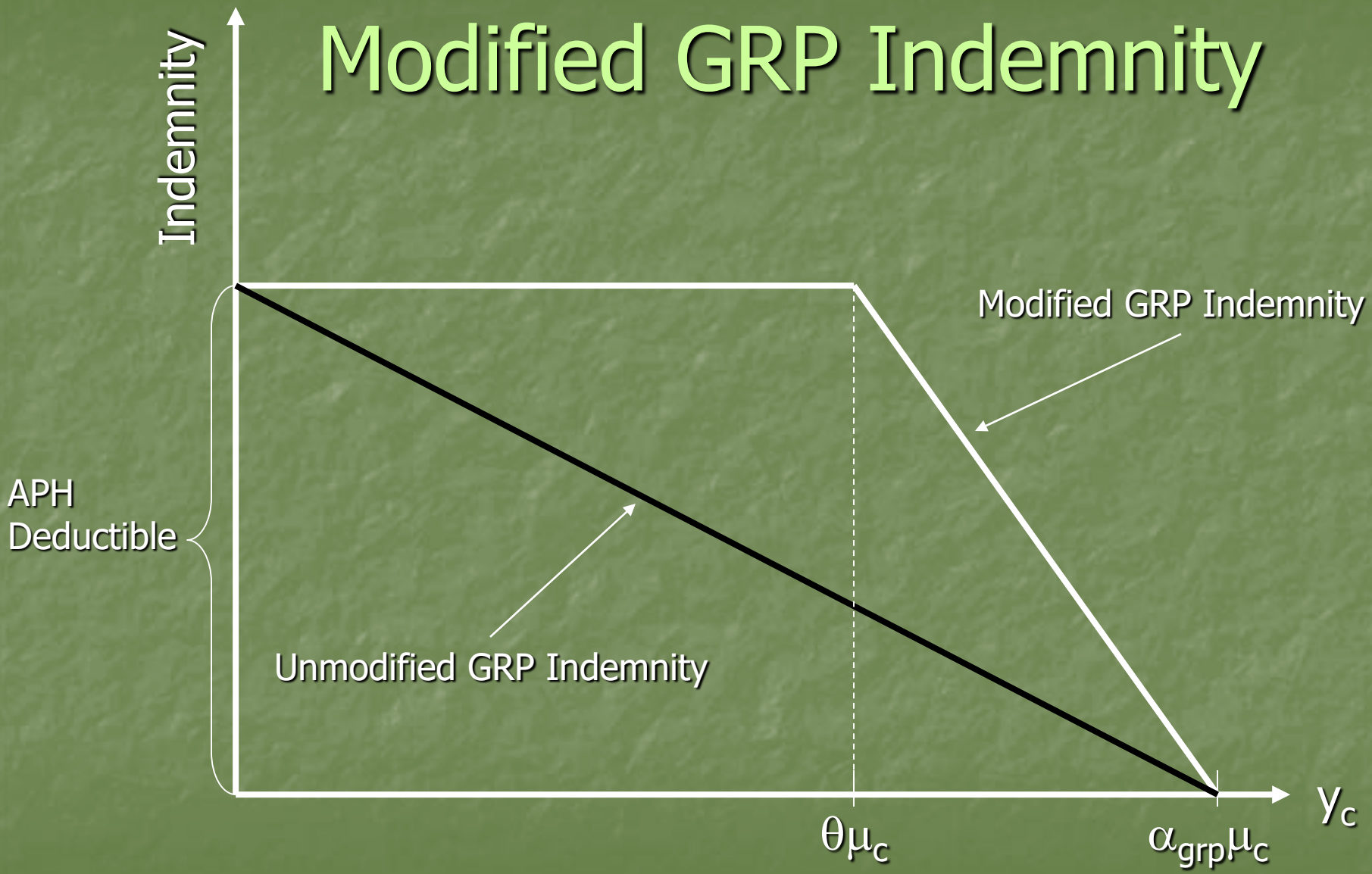


Problem with unmodified GRP

- GRP only pays total liability D_{aph} if $y_c = 0$
- Very unlikely, even in high risk areas
- Need accelerated indemnities
- Modify GRP indemnity further: Same y_c trigger of $\alpha_{grp}\mu_c$, but full payout of APH deductible by $y_c = \theta\mu_c$, $0 \le \theta \le \alpha_{grp}$

$$I_{mgrp} = \min\left\{ D_{aph} \times \max\left(\frac{\alpha_{grp}\mu_c - y_c}{\alpha_{grp}\mu_c - \theta\mu_c}, 0 \right), D_{aph} \right\}$$

Modified GRP Indemnity



Questions on how these policies work???

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Overview Economic Analysis of SDC

- Effect of SDC on certainty equivalents
- Effect of SDC on optimal coverage level
- Examine farmer certainty equivalent ($/ac) assuming negative exponential utility (CARA) and coverage level chosen optimally
- Use Monte Carlo integration to estimate farmer expected utility, then calculate certainty equivalents

Modeling Stochastic Relation between Farm and County Yields

- With SDC, farmer indemnities depend on both the farm yield and the county yield
- Certainty equivalent and optimal coverage depend on how model relation btwn yields
- Models used in literature
  - Additive: $y_f = \beta_f y_c + \varepsilon_f$ } less general
  - Multiplicative: $y_f = y_c \eta_f$ } less general
  - Hierarchical: $y_f \sim f(y_f | y_c)$ more general
  - Joint Density: $g(y_f, y_c)$ more general

Modeling Stochastic Relation between Farm and County Yields

- Given mean and variance of county yield
- Additive and Multiplicative:
  - Setting farm mean and variance sets correlation between farm and county yields
- Joint Distribution:
  - Correlation between farm and county yields can be set separate from farm mean and variance
- Hierarchical:
  - Depends on number of parameters of the conditional density for farm yield

Main Point

- I use a joint density for farm and county yields that separately specifies the county mean and variance, the farm mean and variance, and the correlation between farm and county yields
- Parameters μ_c, σ_c, μ_f, σ_f, and ρ_{fc} fully describe farm and county yields
- Additive and Multiplicative would only have μ_c, σ_c, μ_f, and σ_f as free parameters

Monte Carlo Analysis

- Specify parameters: μ_c, σ_c, μ_f, σ_f, and ρ_{fc}, plus premiums, price, coverage levels and coefficient absolute risk aversion R_a
- Draw county and farm yields
- Determine indemnities, returns and utilities for each set of yield draws
- Calculate expected utility for parameter set as simple average of all utilities: EU = Average(u_i)
- Calculate certainty equivalent: CE = – ln(1 – EU)/R_a

Distribution of Yields

- County yield: lognormal distribution
  - Mean = GRP 2007 expected county yield
  - St. Dev. set to match 90% GRP premium rate
- Farm yield: beta distribution
  - Mean = 75% or 125% county mean
  - St. Dev. set to match 65% APH premium rate
  - Min = 0, Max = mean + 2 st. dev.
- Farm-county correlation = 0.5 and 0.8
- Draw correlated random yields using Richardson and Condra's method

Drawing Correlated Pseudo-Random Variables

1. Calculate L = Cholesky decomposition of var-cov matrix given by σ_c, σ_f and ρ_{fc}
2. Draw n_1 and $n_2 \sim N(0,1)$ i.i.d.
3. Calculate $t_i = L_{i1}n_1 + L_{i2}n_2$
4. Calculate $v_i = \Phi(t_i) \sim$ uniform (0,1)
5. Calculate yields $y_j = F_j^{-1}(v_i)$

Premiums and Indemnities

- Determine Actuarially Fair Premiums, then apply current premium subsidy rates
- Indemnities:

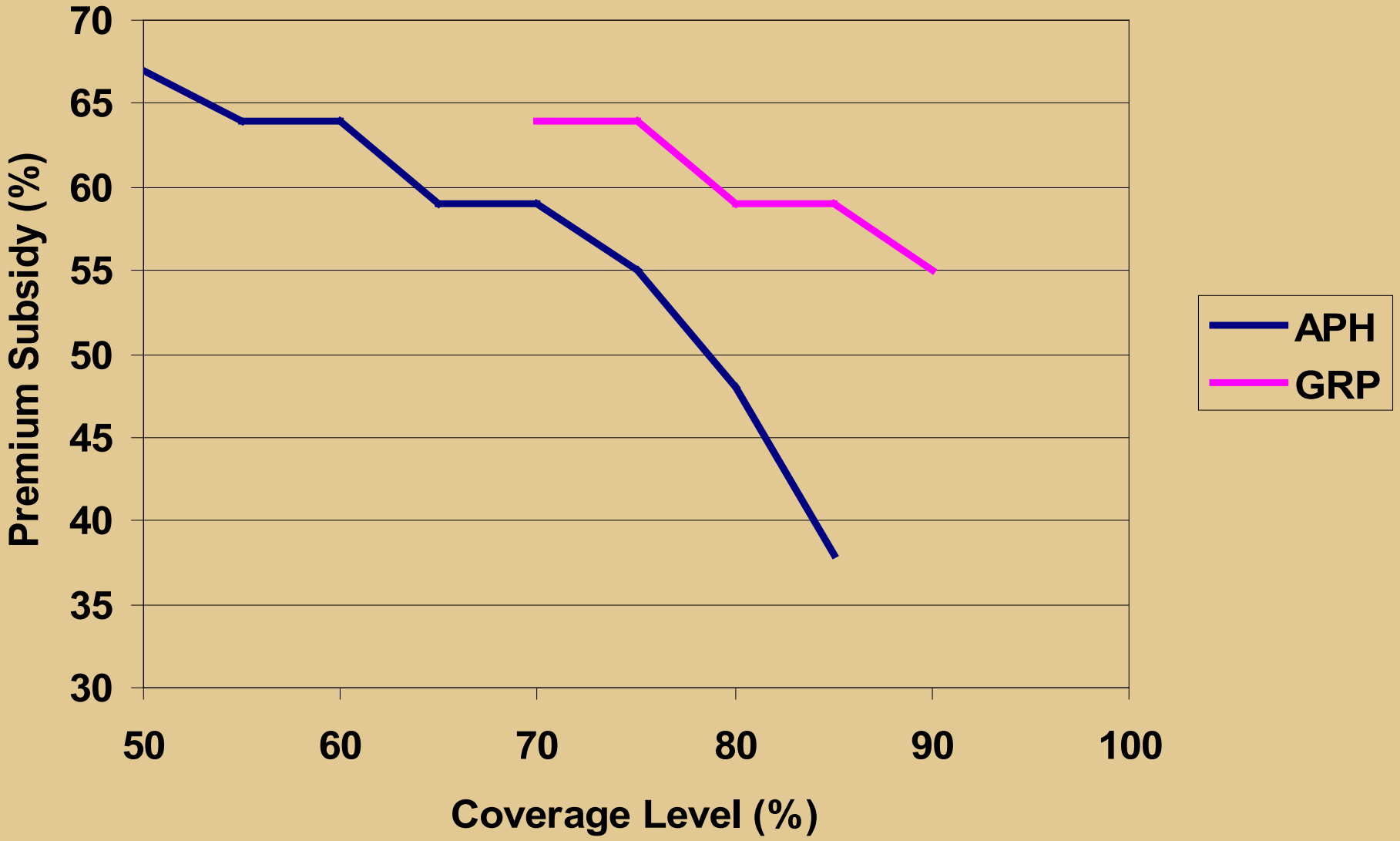
$I_{aph} = P_{aph} \times \max\{\alpha_{aph}\mu_f - y_f, 0\}$

$I_{grp} = MP_{grp} \times \max\{(\alpha_{grp}\mu_c - y_c)/(\alpha_{grp}\mu_c), 0\}$

$I_{sdc} = I_{aph} + I_{mgrp}$

$$I_{mgrp} = \min\left\{D_{aph} \times \max\left(\frac{\alpha_{grp}\mu_c - y_c}{\alpha_{grp}\mu_c - \theta\mu_c}, 0\right), D_{aph}\right\}$$

Federal Premium Subsidy Rate



Revenue and Utility

- Revenue
  - $\pi_0 = py_f$
  - $\pi_{grp} = \pi_0 - M_{grp}(\alpha_{grp}) + I_{grp}(\alpha_{grp})$
  - $\pi_{aph} = \pi_0 - M_{aph}(\alpha_{aph}) + I_{aph}(\alpha_{aph})$
  - $\pi_{sdc} = \pi_{aph} - M_{mgrp}(\alpha_{aph}) + I_{mgrp}(\alpha_{aph})$
  - p = price, M_i = premium and I_i = indemnity
- Utility: $u_i = 1 - \exp(-R_a\pi_i)$
- Expected Utility: EU = avg(u_i) over all i
- Certainty Equivalent: $CE = -\ln(1 - EU)/R_a$

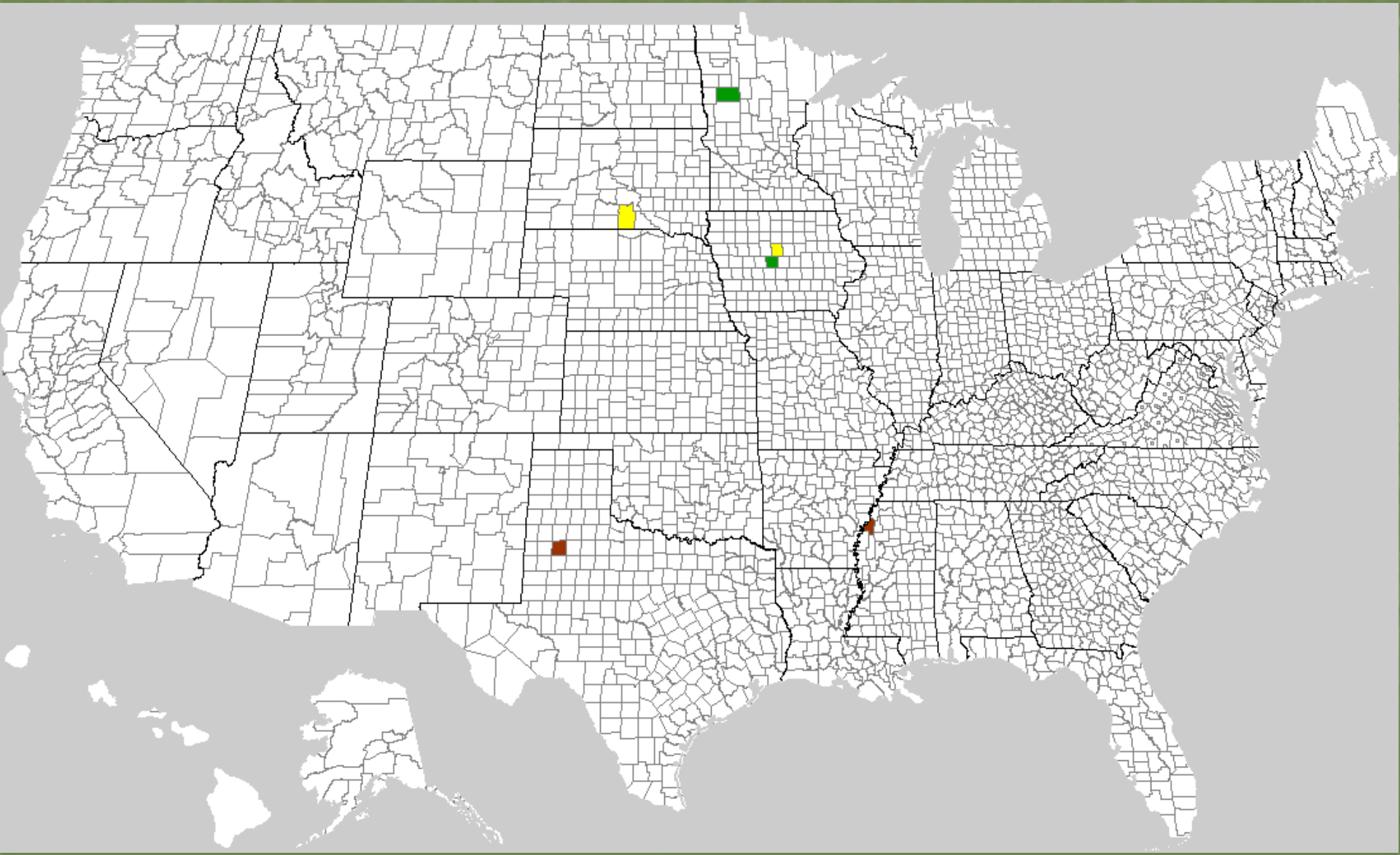
Expected Utility Maximization

- Assume farmers choose APH coverage level optimally (maximize expected utility)
  - For APH alone
  - For APH as part of SDC
- Fix GRP coverage level at 90% and use 100% price election for APH, as these are optimal ex ante
- Find certainty equivalent for all APH coverage levels to identify EU maxing α_{aph}

Scenarios Analyzed

- Three Crops: Corn, Cotton, Soybeans
- Two types of counties
  - High risk counties (marginal cropping)
  - Low risk counties (good cropping)
- Two farm types in each county
  - Below Average (μ_f = 75% of μ_c)
  - Above Average (μ_f = 125% of μ_c)
- Two Measures for Impact of SDC
  - Increase in CE ($/ac) compared to APH alone
  - Change in optimal APH coverage level

Corn: Hamilton, IA; Tripp, SD — YELLOW
Soybeans: Boone, IA; Becker, MN — GREEN
Cotton: Coahoma, MS; Lubbock, TX — BROWN

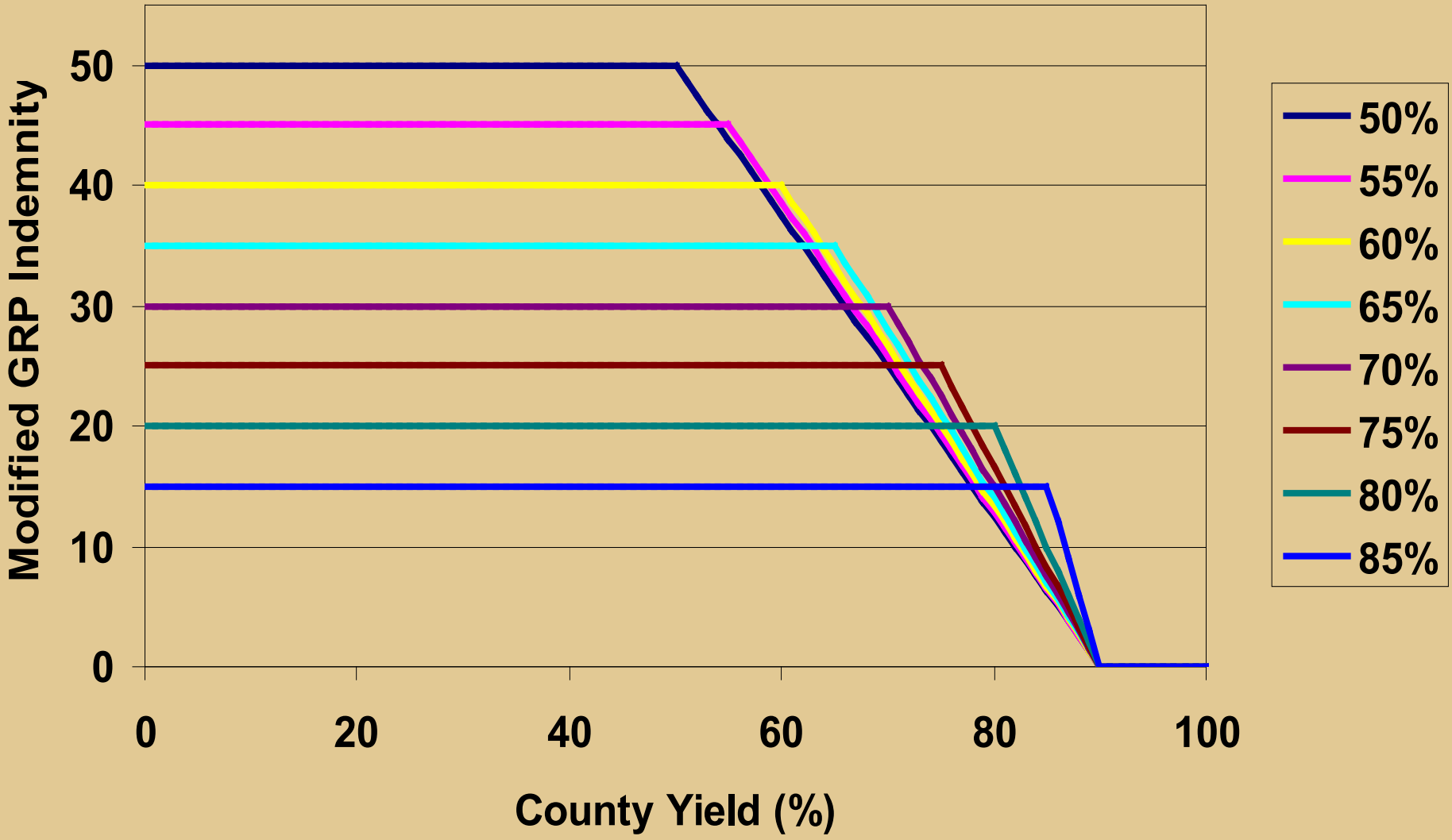


	Corn		Soybeans		Cotton	
County	Tripp	Hamilton	Becker	Boone	Lubbock	Coahoma
Mean	56.9	176.4	28.3	46.2	232.0	852
St Dev	18.6	28.3	8.43	7.39	115.9	212.1
CV	32.7%	16.0%	29.8%	16.0%	50.0%	24.9%
Farm: high risk (μ_f 75% of μ_c)						
Mean	43.0	132.0	21.0	35.0	174.0	639.0
St Dev	37.3	38.0	12.2	10.4	199.5	277.3
CV	86.7%	28.8%	58.0%	29.7%	115%	43.4%
Farm: low risk (μ_f 125% of μ_c)						
Mean	71.0	221.0	35.0	58.0	290.0	1065.0
St Dev	39.5	54.6	14.3	14.4	227.1	399.8
CV	55.6%	24.7%	40.9%	24.8%	78.3%	37.5%

More parameters

- Coefficient of absolute risk aversion
  - Set so risk premium = 30% revenue st. dev. when no insurance is used
- Prices: used APH prices for 2007
  - Corn $3.50/bu Soybeans $7/bu
  - Cotton $0.52/lb in TX, $0.53 in MS
- Full GRP payout as % county mean (θ)
  - No guidance in Farm Bill proposal
  - Set equal to APH coverage level: $\theta = \alpha_{aph}$

Indemnity Schedule

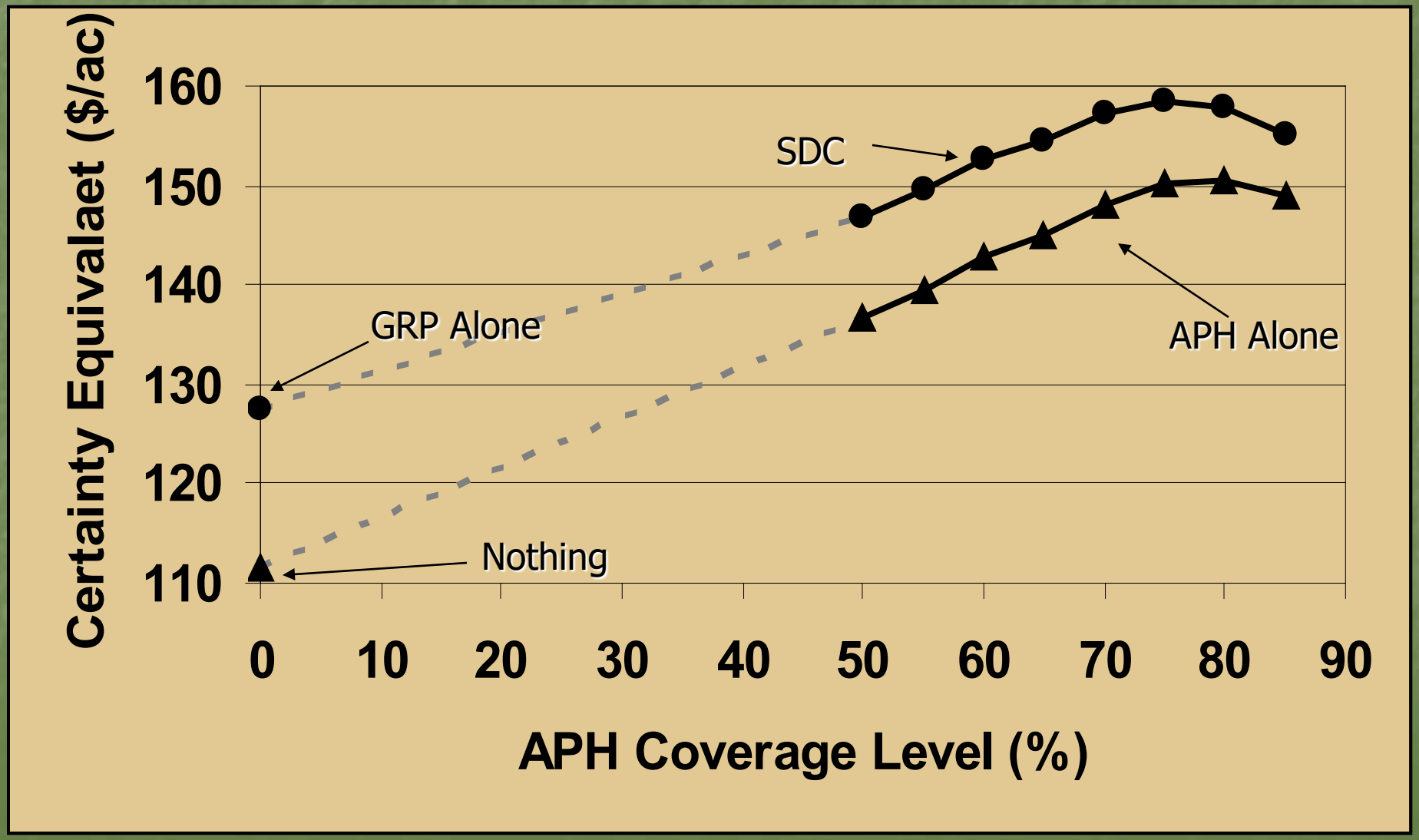


Results

- First plots of certainty equivalent (CE) vs coverage level (α_{aph}) to show derivation of optimal α_{aph} and CE for APH alone and APH with SDC
- Bar plots of how SDC affects optimal certainty equivalent and optimal coverage
- Summarize general findings

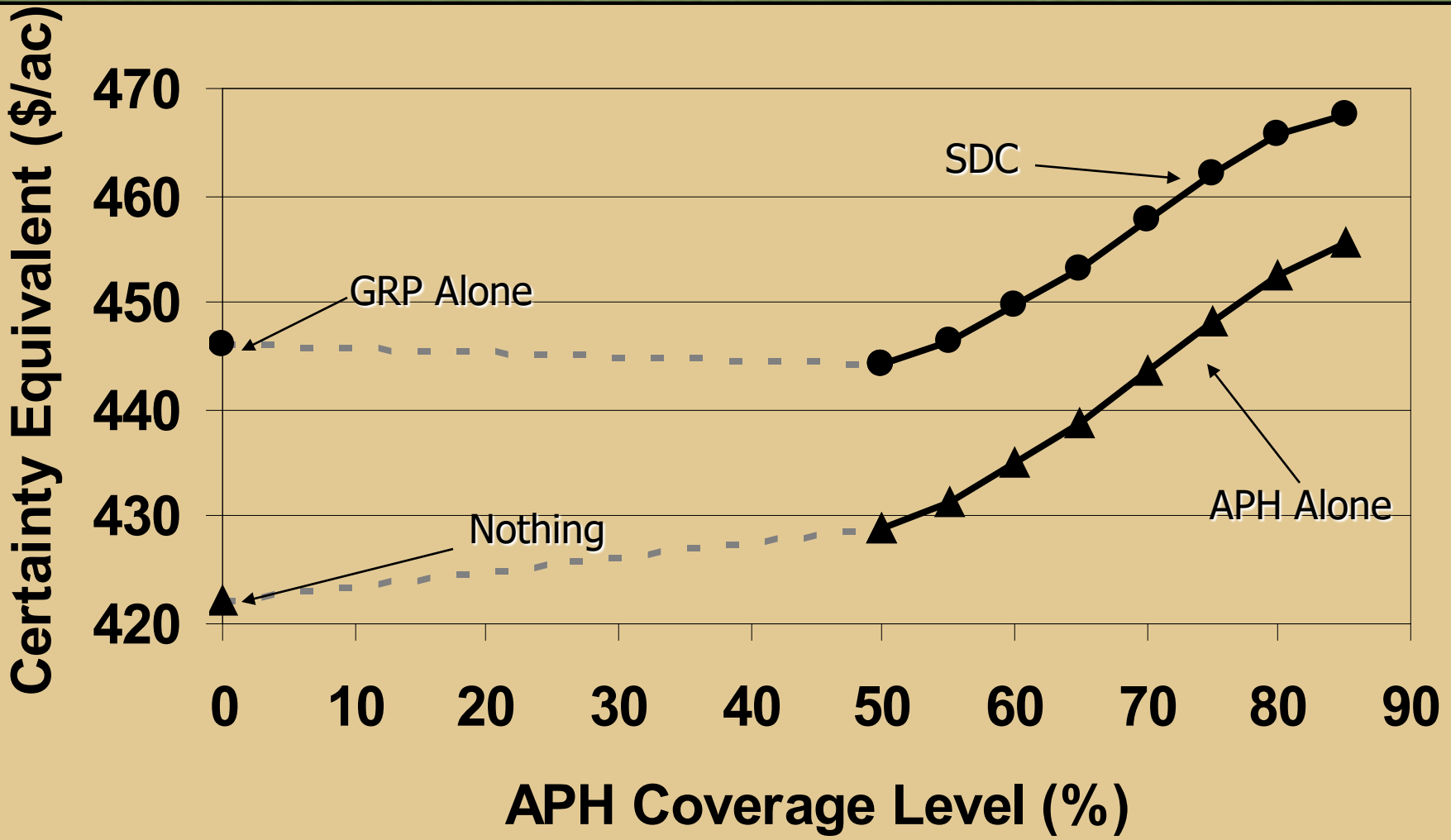
Corn: Tripp, SD ($\mu_f = 0.75\mu_c$, $\rho_{fc} = 0.5$)

Optimal α_{aph} = 80% w/ APH alone, 75% w/ SDC

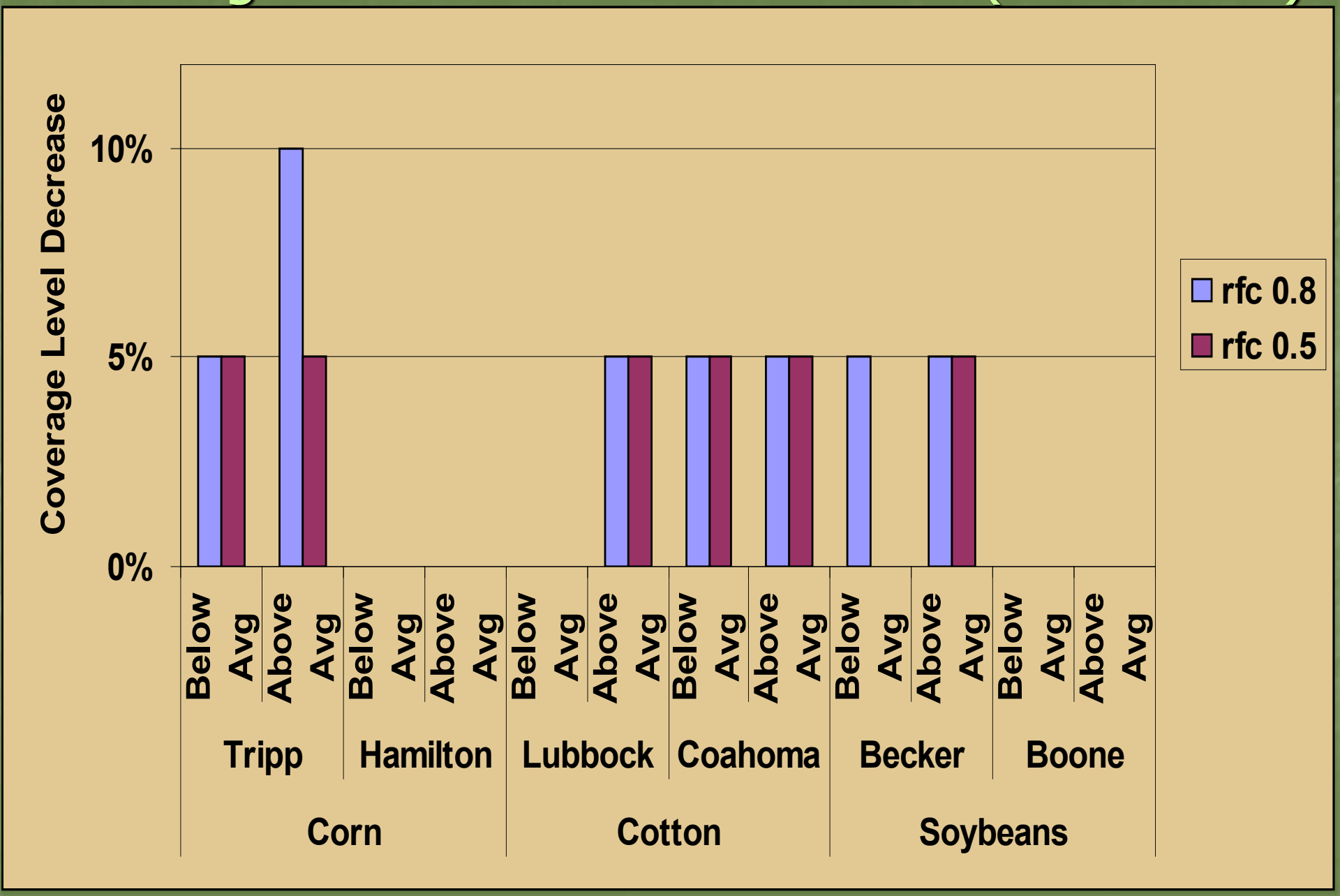


Corn: Hamilton, IA ($\mu_f = 0.75\mu_c$, $\rho_{fc} = 0.8$)

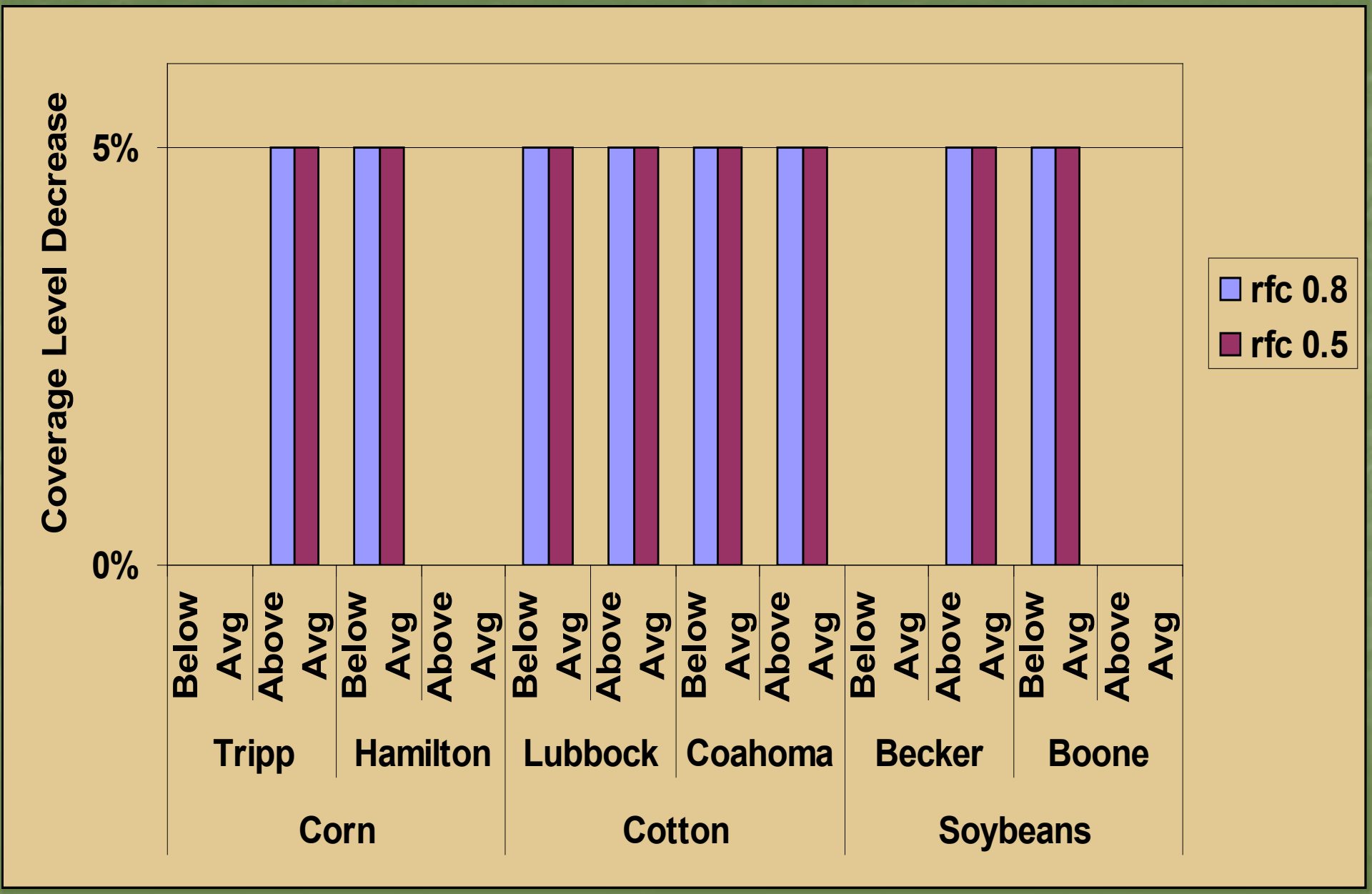
Optimal α_{aph} = 85% w/ APH alone and w/ SDC



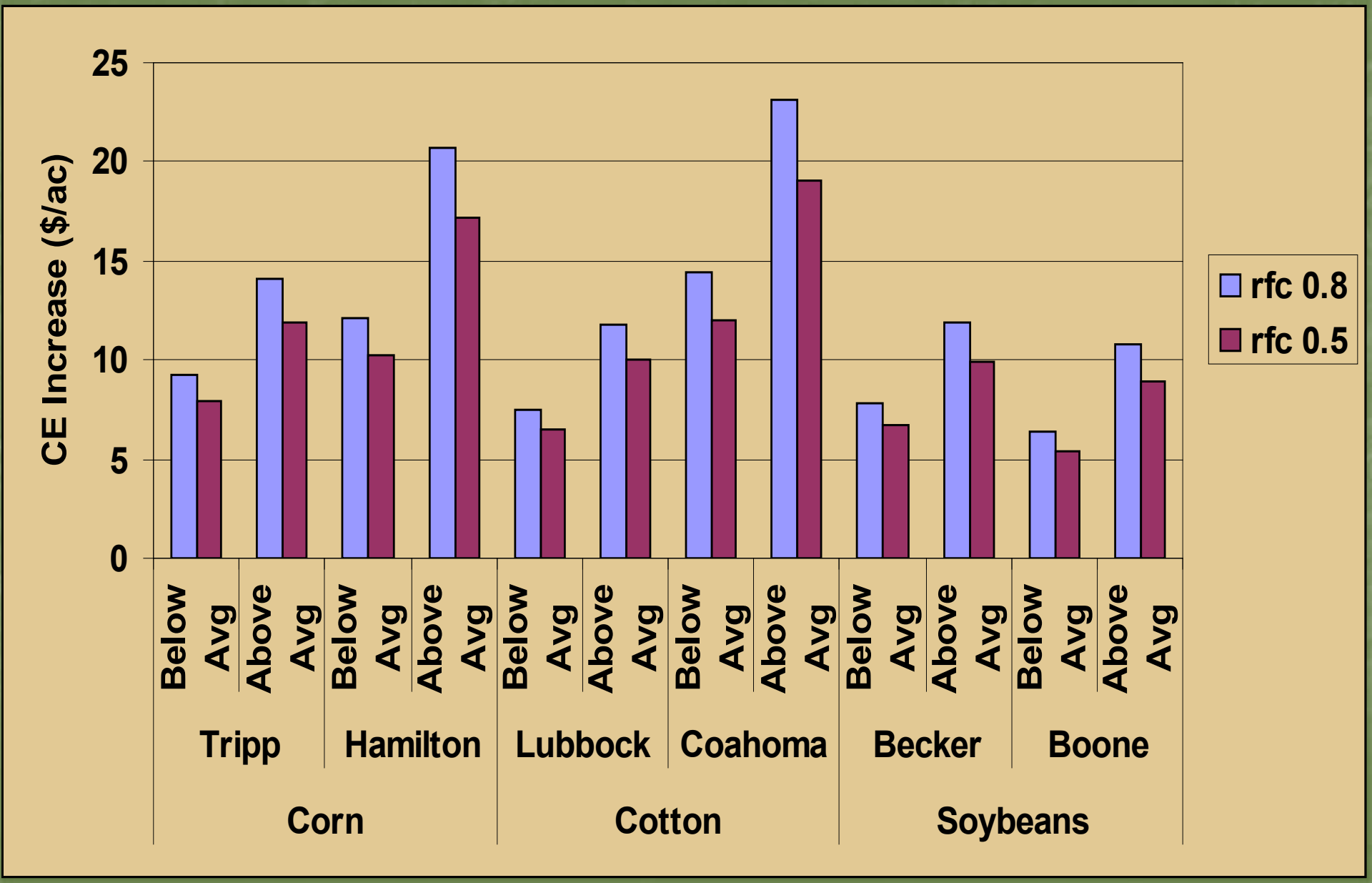
Coverage Level Decrease with SDC (risk averse)



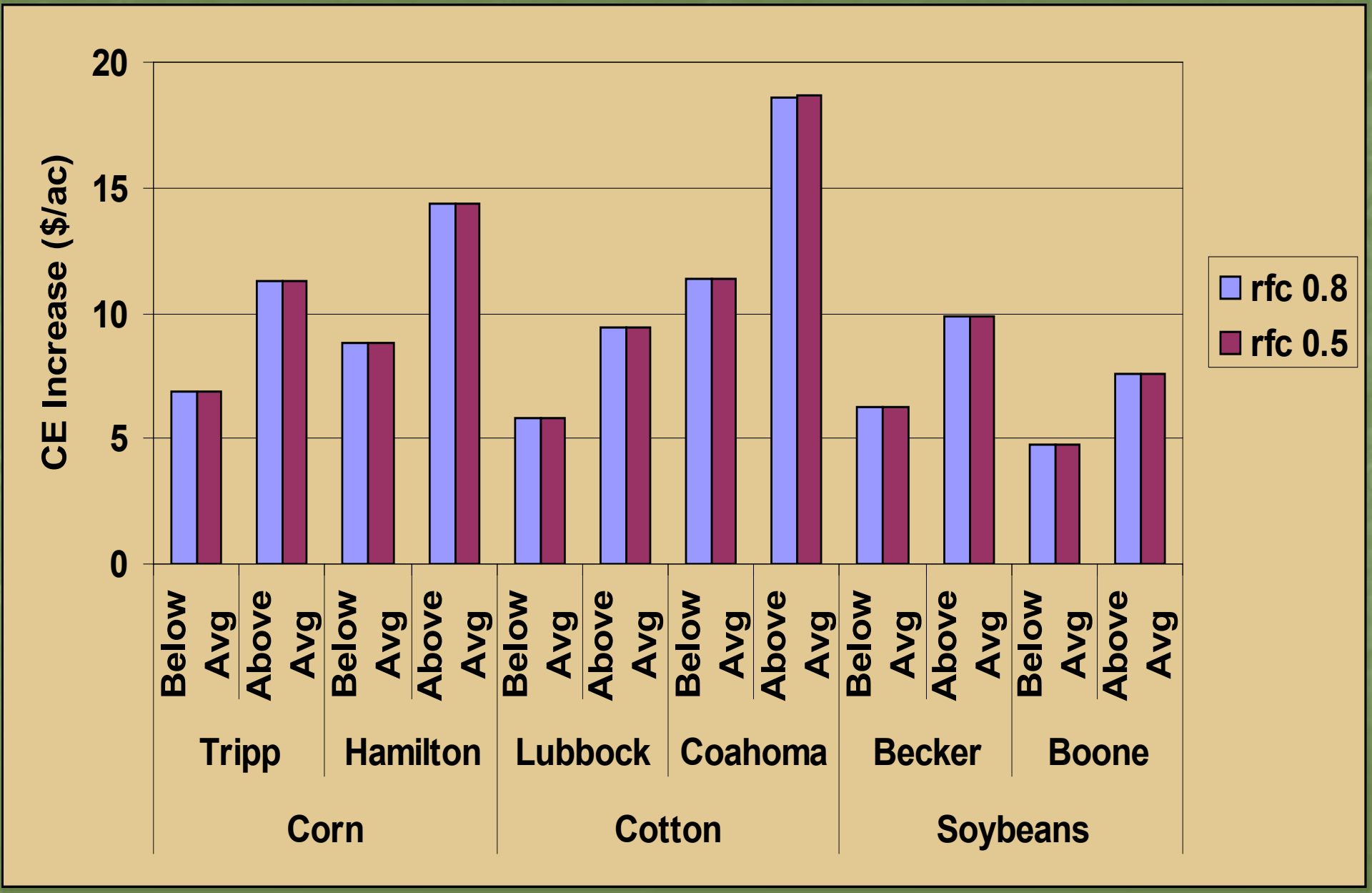
Coverage Level Decrease with SDC (risk neutral)



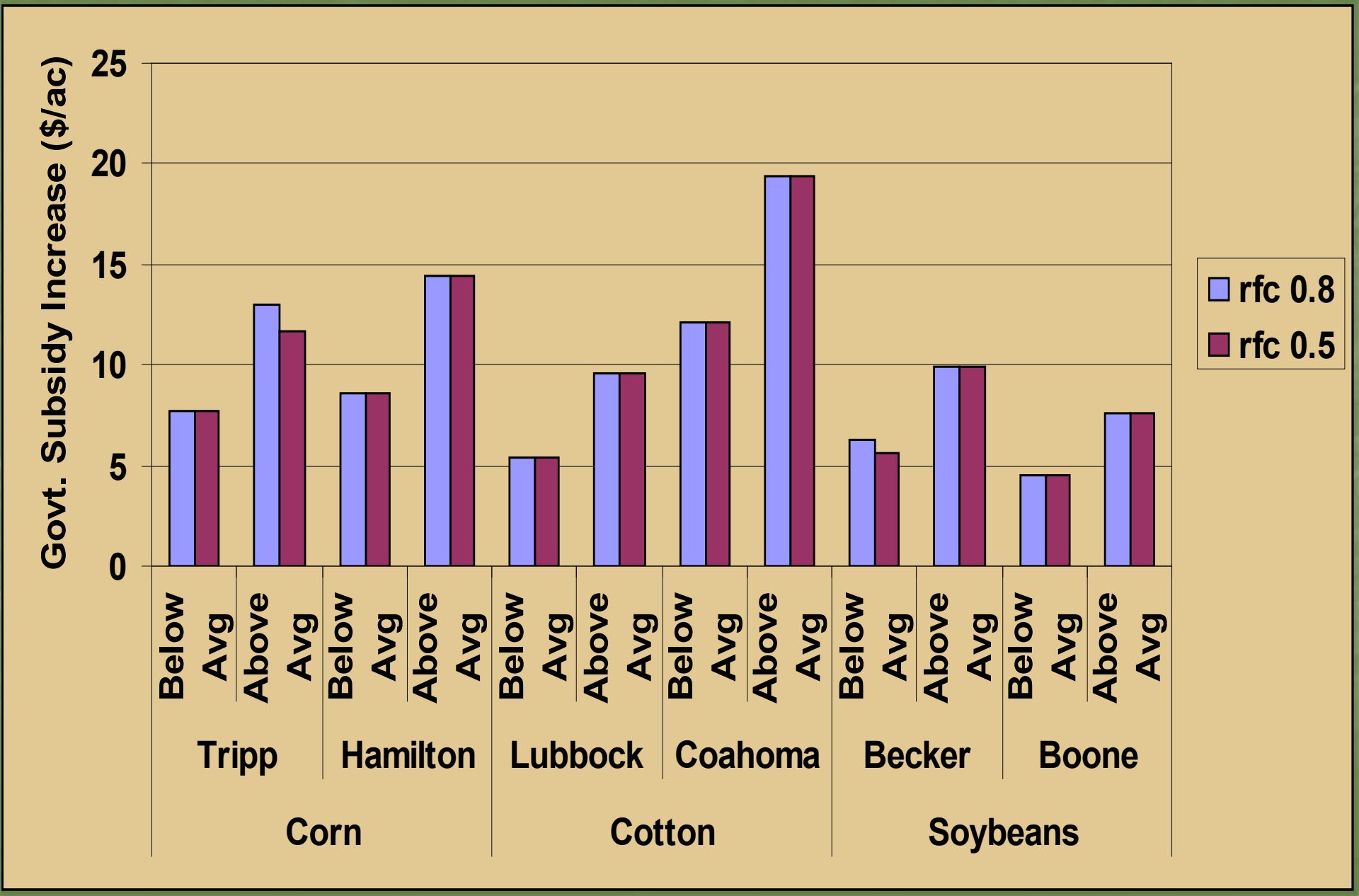
CE Increase with SDC (risk averse)



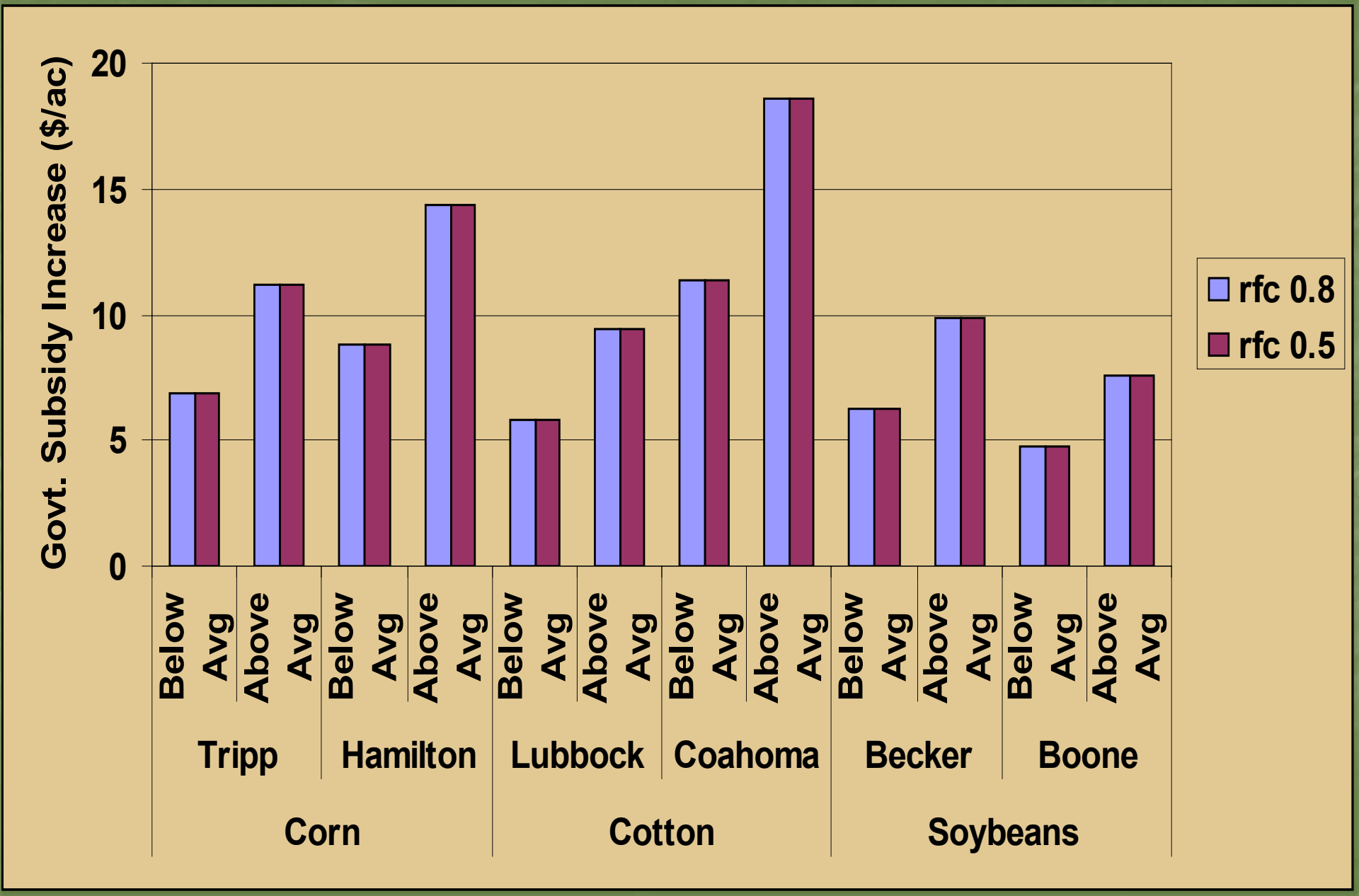
CE Increase with SDC (risk neutral)



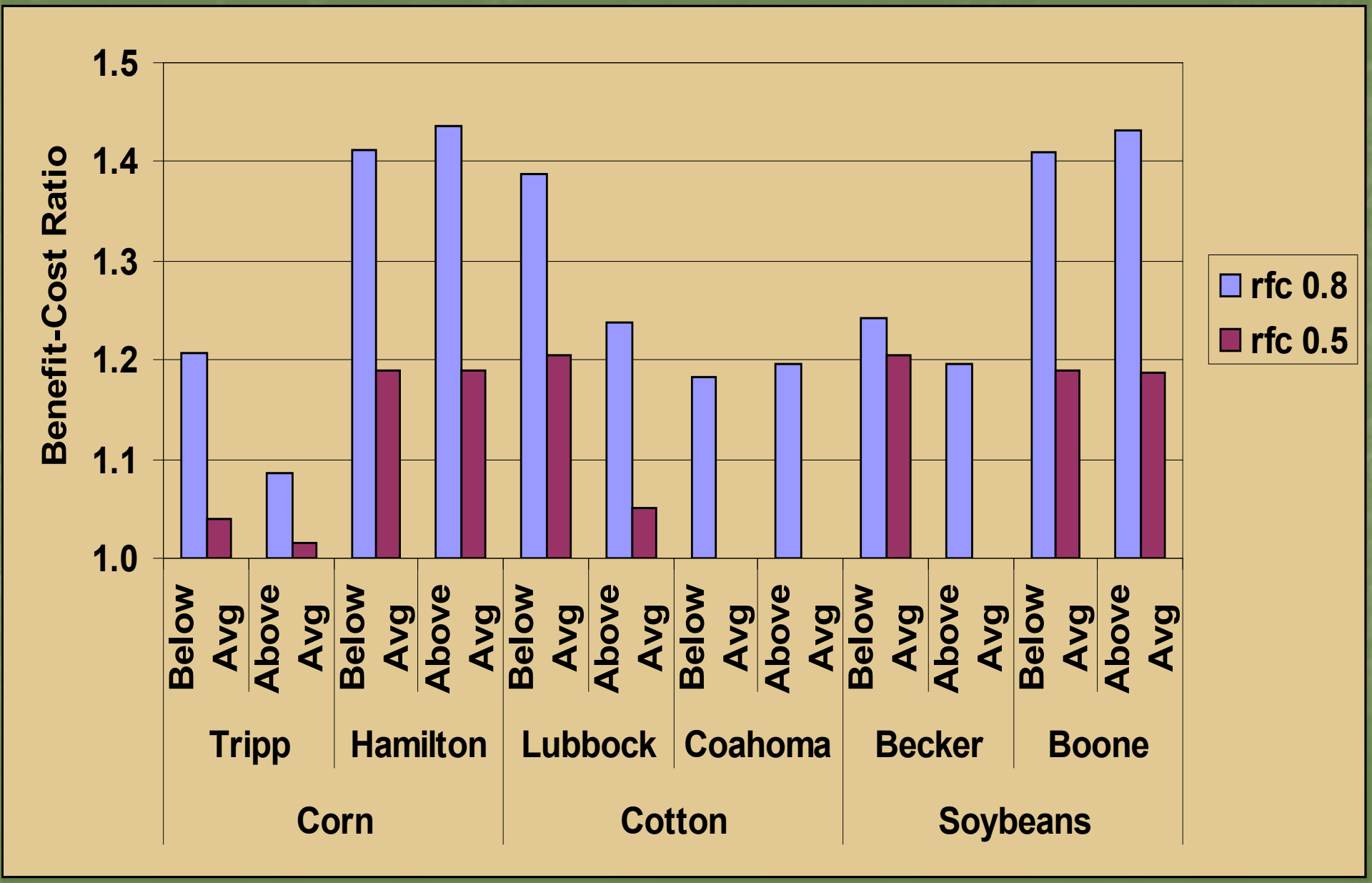
Govt. Subsidy Increase with SDC (risk averse)



Govt. Subsidy Increase with SDC (risk neutral)



Benefit-Cost Ratio for Govt. Funds



Summary: Impact on Farmer CE

- SDC Welfare Benefit/CE increase ($/ac)
  - Ranged $5-$23/ac
  - Larger for growers with above average yields and more correlated with county yields
  - Larger benefit in low risk areas for corn and cotton, but in high risk areas for soybeans
  - Corn and cotton benefits similar and larger than for soybeans

Summary: APH Coverage Level

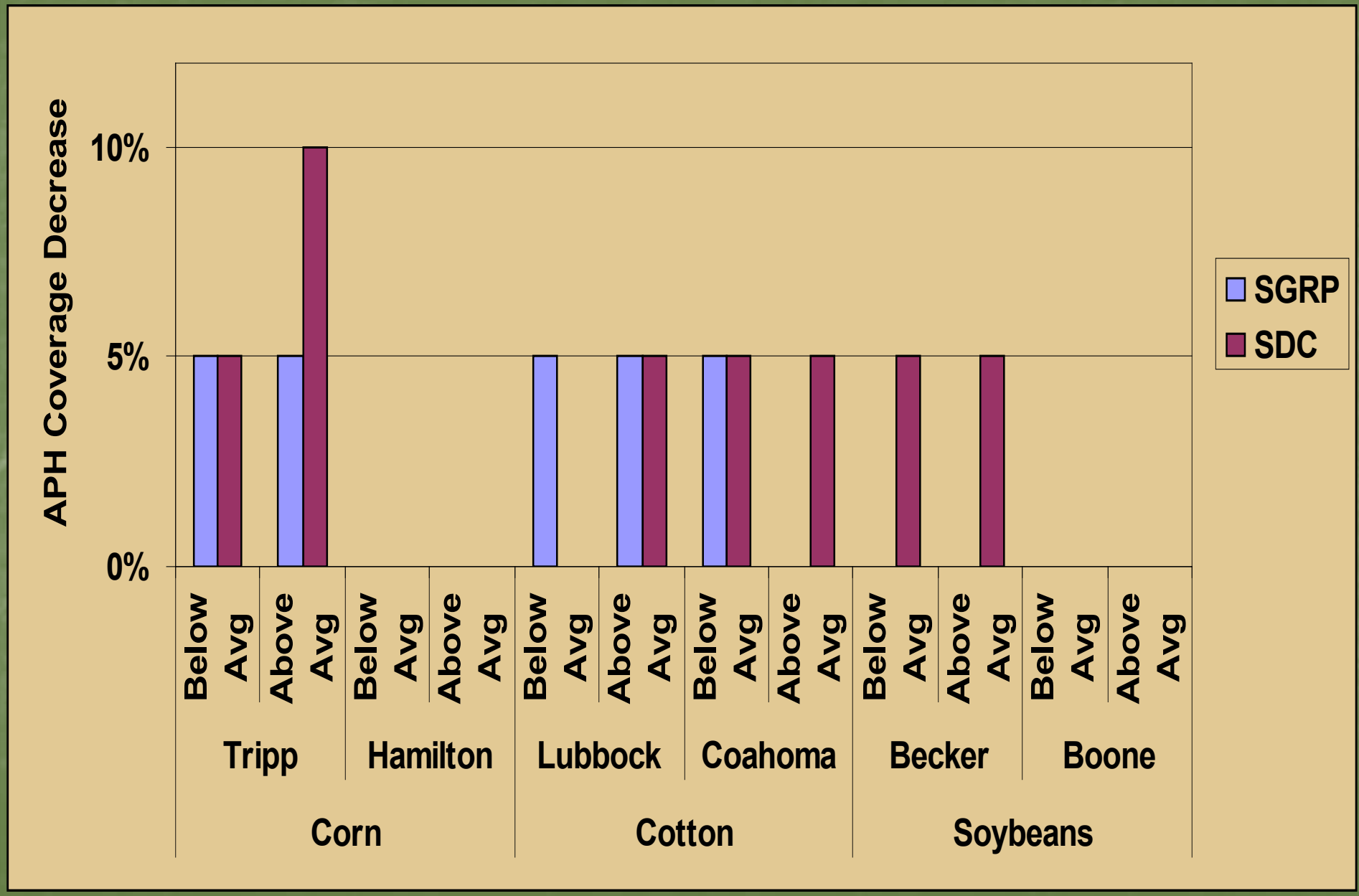
- Optimal APH coverage level decrease
  - Decreased 5-10 percentage points in high risk corn and soybean areas and cotton areas
  - No effect in low risk corn and soybean areas
- Implication as shift liability from individual to areawide policy
  - Reduced potential for moral hazard, fraud, and program abuse
  - Lower loss adjustment and administrative costs

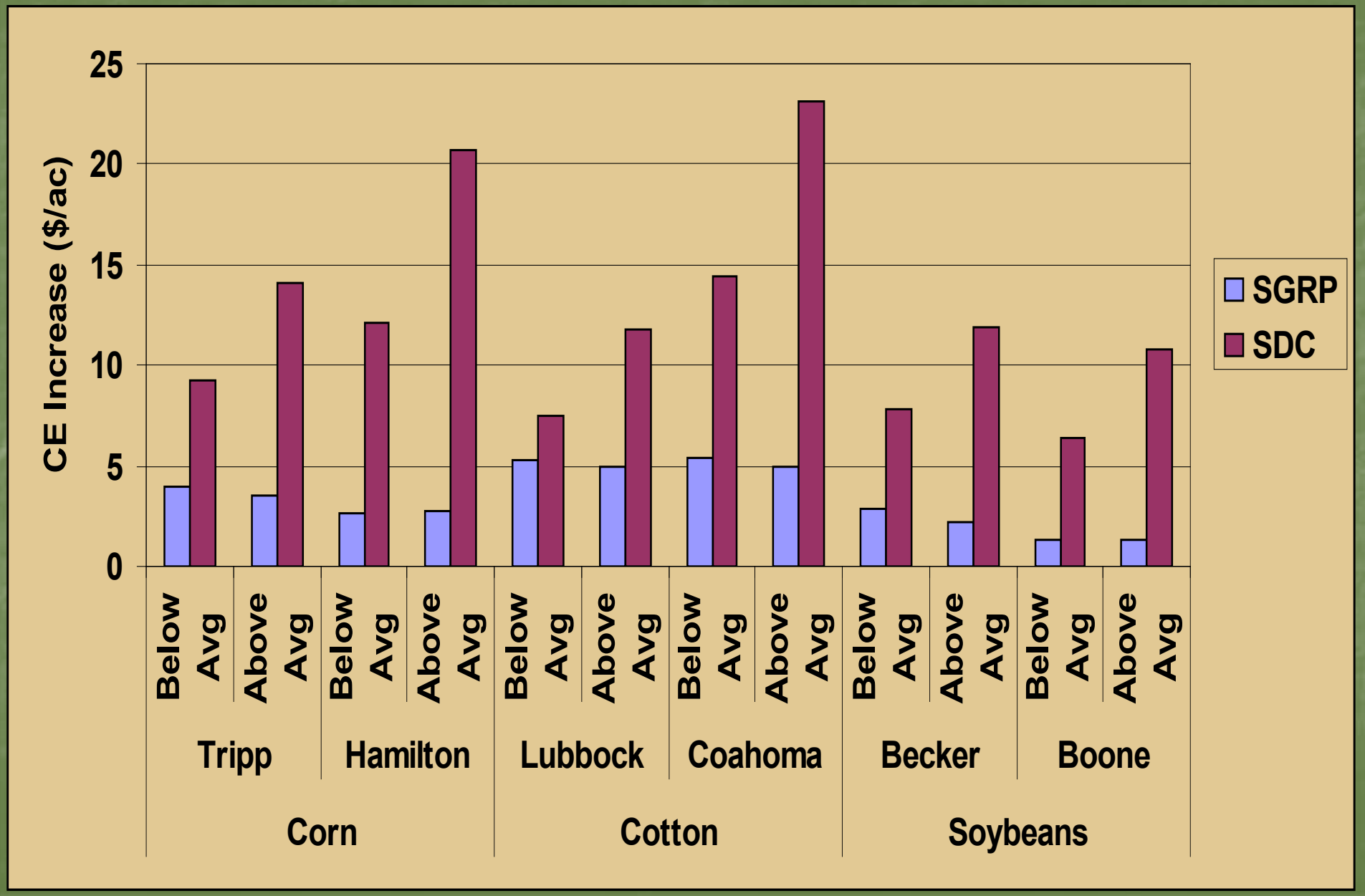
Summary: Government Benefit-Cost Ratio

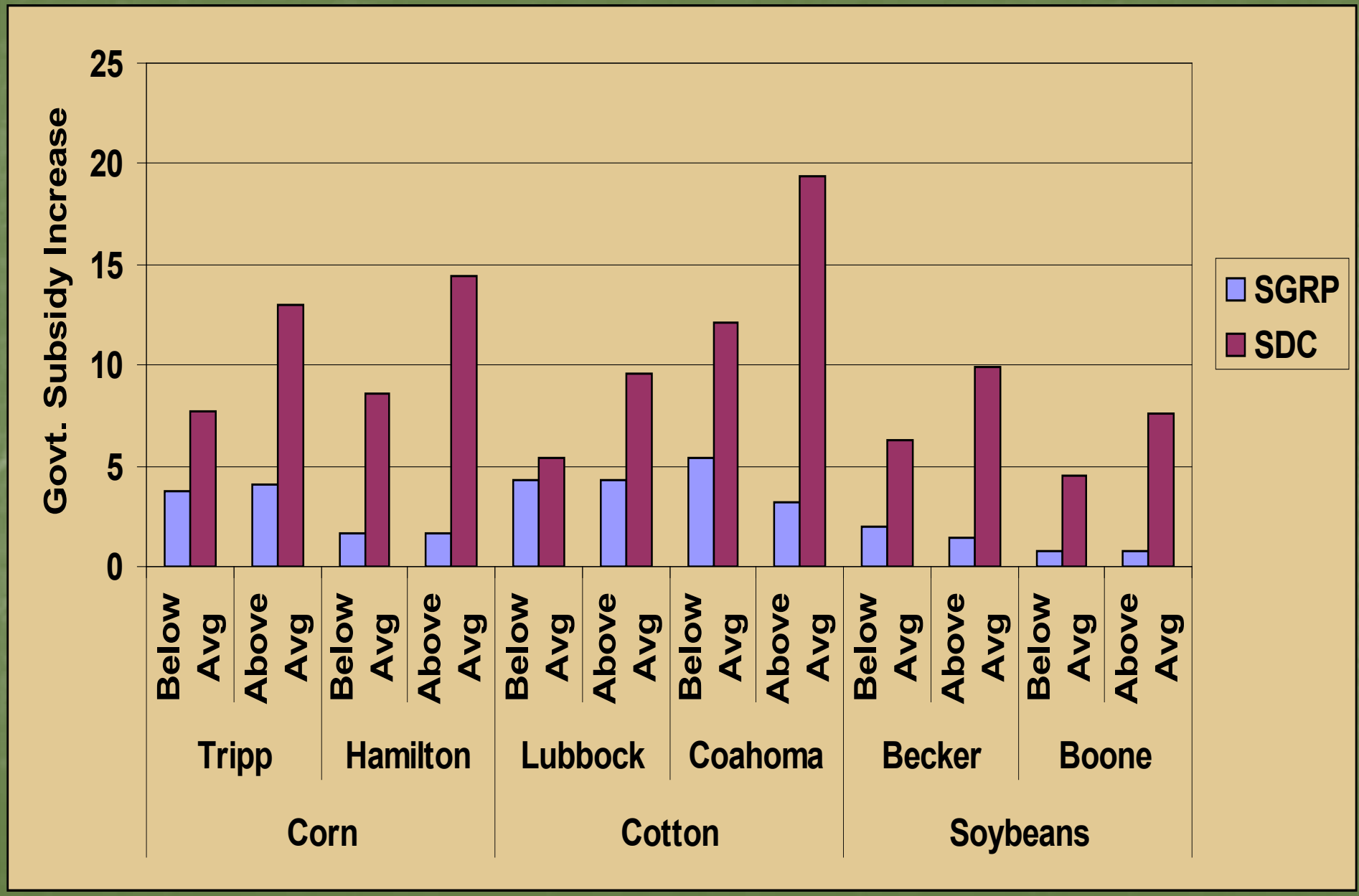
- Ratio of farmer CE increase to govt. subsidy increase
  - Higher when more correlated w/ county yields
  - Higher where optimal APH coverage not reduced
    - Higher in low risk corn and soybean areas
    - Lower in high risk corn and low risk cotton

Knight, Coble, and Mitchell

- Report for House Ag Committee's deliberations on Farm Bill
- Compared SDC to SGRP


APH Coverage Decrease
10%
5%
0%
SGRP
SDC
Below Avg
Above Avg
Tripp
Hamilton
Lubbock
Coahoma
Becker
Boone
Corn
Cotton
Soybeans


CE Increase ($/ac)
25
20
15
10
5
0
SGRP
SDC
Below Avg
Above Avg
Tripp
Hamilton
Lubbock
Coahoma
Becker
Boone
Corn
Cotton
Soybeans


Govt. Subsidy Increase
25
20
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SGRP
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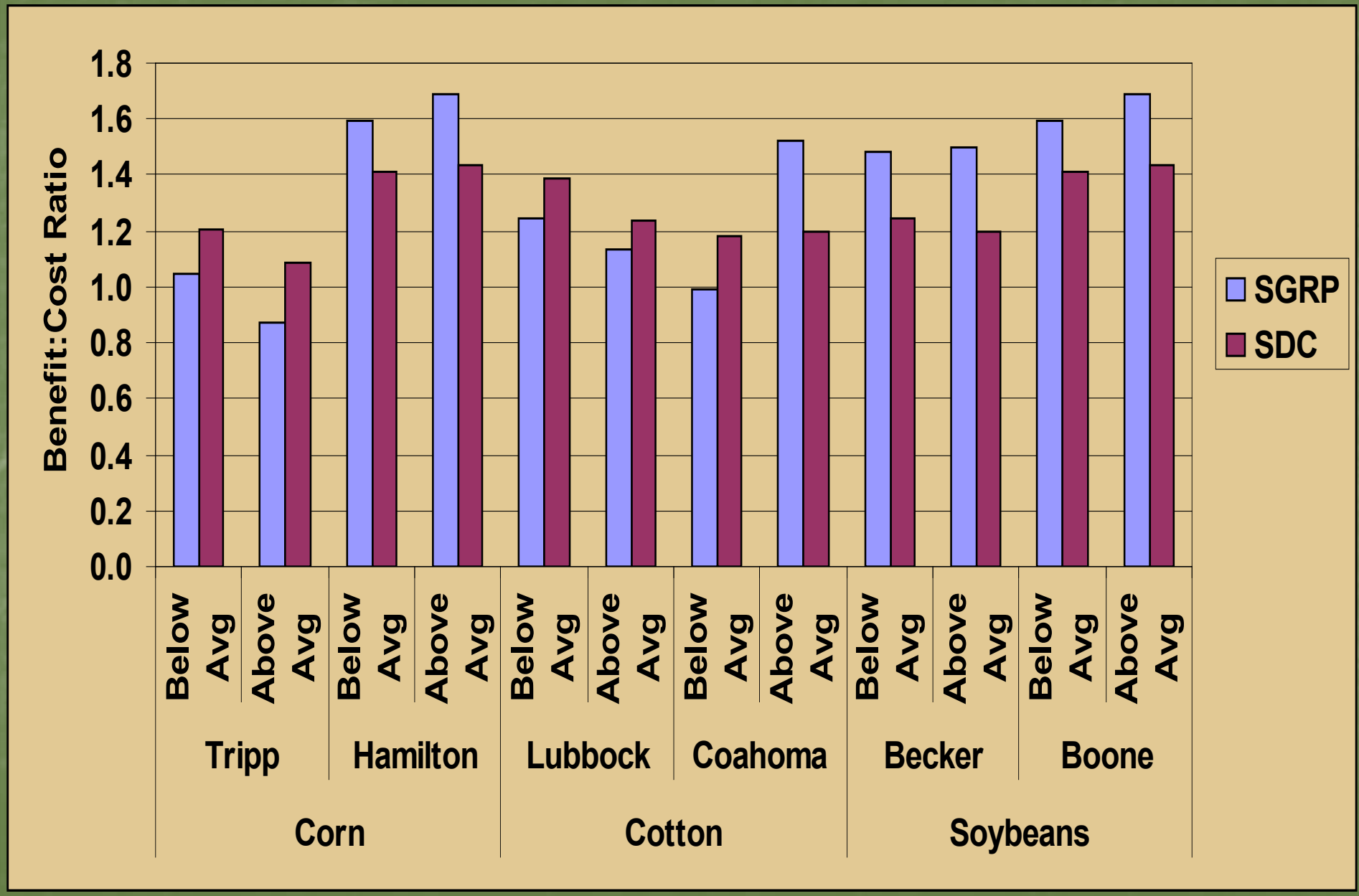
Benefit:Cost Ratio
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
SGRP
SDC
Below Avg
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Tripp
Hamilton
Lubbock
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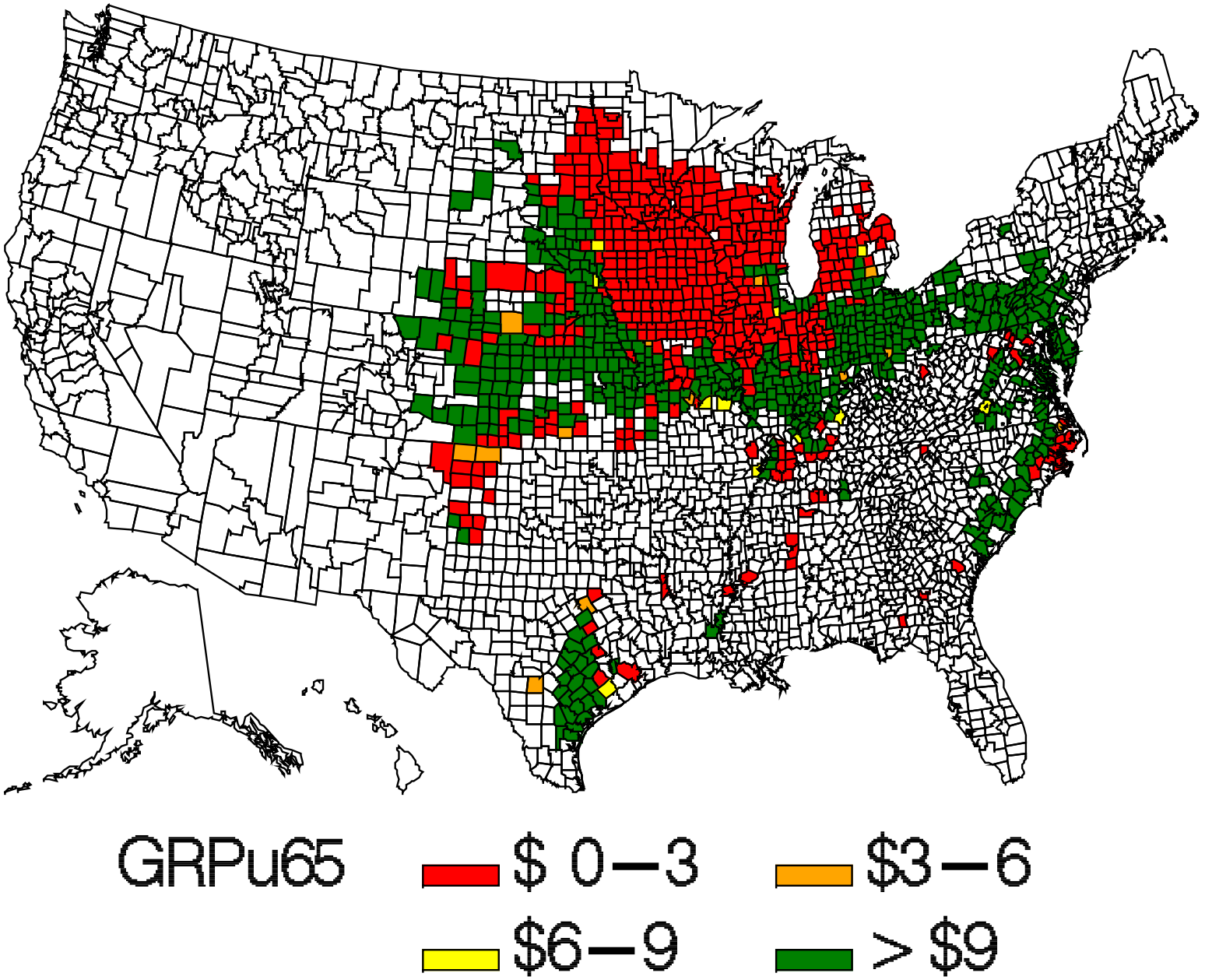
Corn
Cotton
Soybeans

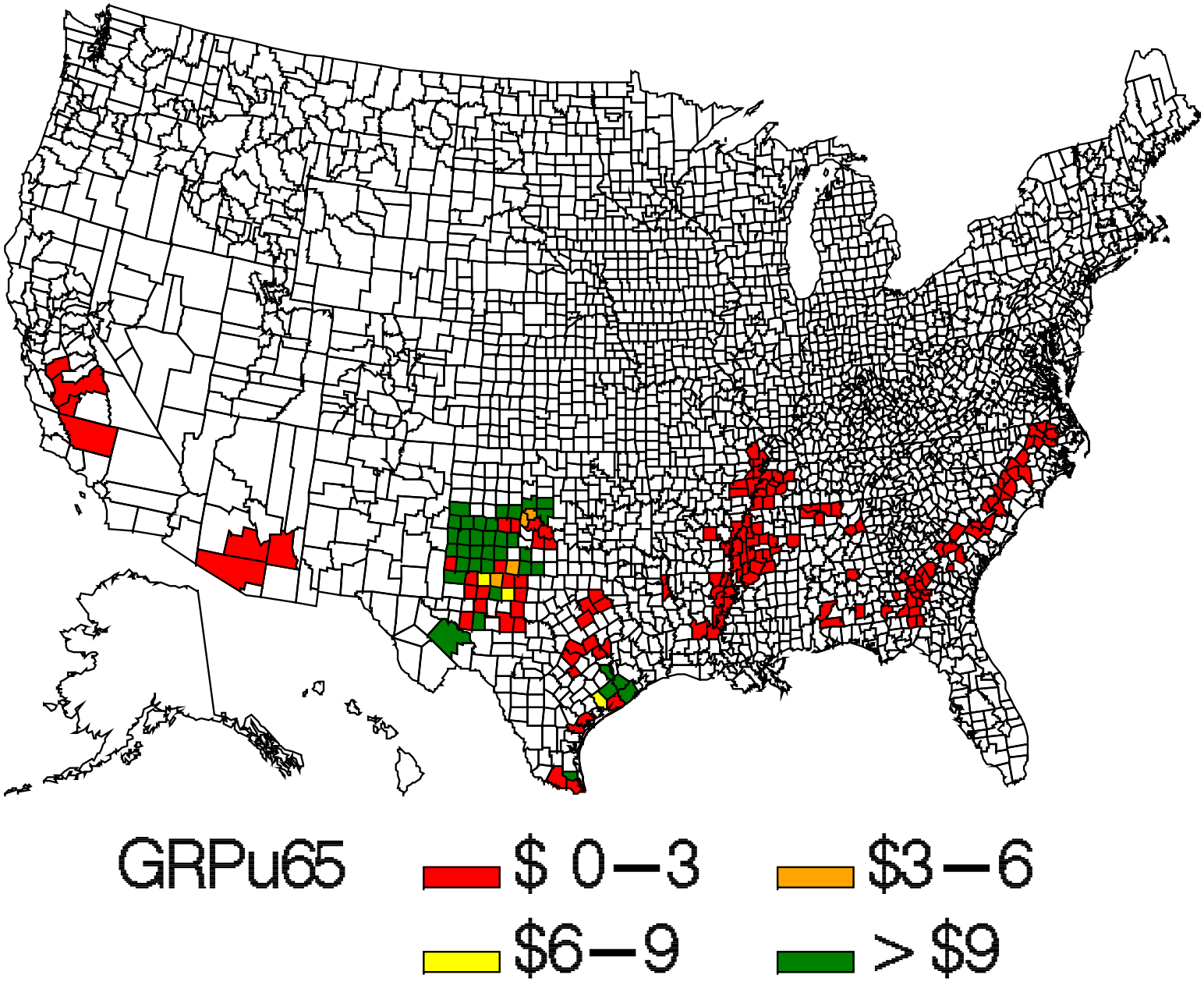
Knight, Coble, and Mitchell

- Wrote report for House Ag Committee's deliberations on Farm Bill
- Plots showing increase in expected return with SDC for corn, cotton, and soybeans for US counties, assuming 65% APH
  - Expected return = E[Premium – Indemnity]
  - Risk neutral, so no risk benefit
  - Non-endogenous APH coverage level

Per Acre Net Payment for Corn 90% SDC with 65% APH



Per Acre Net Payment for Cotton 90% SDC with 65% APH



Per Acre Net Payment for Soybean 90% SGRP with 65% APH