Review of Adjustment in Actual Production History to Establish Insurable Yields: Determination of Actuarially Sound Premium Rates

A Report for USDA Risk Management Agency

March 23, 2015

Sumaria

SUMARIA SYSTEMS, INC. DELIVERABLE NUMBER 4, D13PC00094 TASK ORDER D15PD00049

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Table of Contents

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1.0 Introduction

RMA has been directed to implement Section 11009 of the 2014 Farm Bill. This amendment to §508(g)(4)(C) of the Federal Crop Insurance Act allows producers the option to exclude any recorded or appraised yield for any crop year in which the per planted acre yield in the county is at least 50 percent below the simple average per planted acre yield during the previous ten consecutive crop years. Two additional provisions that affect implementation are that: (a) In any crop year that a county triggers then a producer in a contiguous county is eligible to make such an election as well; and, (b) a separate determination will be made for irrigated and non-irrigated acreage within a county.

The approved yield, as defined by the Crop Insurance Handbook (CIH), is used to establish the guarantee for certain plans of insurance (e.g., Yield Protection and Revenue Protection). The approved yield is based on the grower's actual production history (APH) subject to specified adjustments. Section 11009 modifies the calculation of the APH yield which is used in various aspects of the crop insurance program. In general, the approved yield is computed as the simple average of up to 10 years of producer reported actual yields. However, various adjustments are allowed that result in an approved yield that does not equal the simple average of actual yields reported. These mechanisms include the 60 percent transitional yield (T-Yield) substitution, yield cups (90 percent of the previous approved yield), and the yield floor (percentage of T-Yield depending on number of actual yields).

Currently, in any year when a producer's yield is below 60% of the county T-yield, they may replace that yield with a 'yield plug' (60% of county T-yield) and re-average the yields to generate their approved yield. However, the producer pays a higher premium rate for this coverage based on the *rate yield* – the simple average of a producer's actual yield history without any yield plugs. The use of a rate yield provides a reasonable approximation of the actuarial impact of T-yield plugs, given the magnitude of their effect on approved yields.

1.1 Purpose of the Review

We were charged with the following tasks:

1. Review the adequacy of existing procedures for establishing premium rates given current approved yield calculations. The context of the proposed procedure for rating the APH adjustment is the current procedure for relating rates to the APH record.
2. Review the adequacy of the current procedures as a mechanism to appropriately establish premium rates for Section 11009 of the Agricultural Act of 2014.
3. Provide a draft and final technical report outlining all findings and recommendations, including any programming code or spreadsheets used in the analysis.

As explained to Sumaria Systems, Inc. by RMA personnel, task 1 was intended not as a comprehensive rate review but rather as a review of the actuarial concepts and procedures associated with the Trend-Adjusted APH option. When exercised, this option allows the effective coverage level on an insured unit to exceed the nominal coverage level. Since the Yield Exclusion (YE) provision will also allow effective coverage levels to exceed nominal coverage levels, RMA proposed to extend the Trend-Adjusted APH actuarial procedures for use with the YE provision.

Task 2 asked Sumaria Systems, Inc. to review whether it would be appropriate to extend the Trend-Adjusted APH actuarial procedures for use with the YE provision, as proposed by RMA. The draft report described in task 3 was delivered and reviews of that draft report were received from Bickerstaff, Whatley, Ryan & Burkhalter, Inc. (David Bickerstaff), AgRisk Management (Bruce Babcock), Oliver Wyman Actuarial Consulting, Inc. (Eric Hornick), Nicholas Piggott, Vedenov Consulting (Dmitry Vedenov), and National Crop Insurance Services, Inc. (NCIS). In this final report, one of the recommendations contained in the draft report has been modified to address concerns expressed by the reviewers.

1.2 Context of the Current Rating System

The RMA actuarial process for plans of insurance based on APH yields uses historical loss experience for the crop in the county as the foundation for establishing premium rates for insured units within that county (Coble et al., 2010). Several adjustments to actual loss experience are made to develop a base county rate. For example, adjustments are made to eliminate the impact of replant indemnities, revenue insurance experience is recomputed as if it were a yield insurance policy, and adjustments are made to normalize indemnities to the 65% coverage level. Given recent modifications, 20 years of historical county experience is typically used and weighting of years reflects the weather weighting proposed in Coble et al (2011). Experience for extreme loss years is removed for the county/crop program and placed in an aggregated catastrophic pool. The remaining experience is averaged to derive the base county rate.

1.2.1 Coverage Level Differentials

The base county rate is derived at the 65% coverage level. Individual rates at different coverage levels are then calculated by scaling the 65% rate using coverage level differentials (or coverage level rate relativities). As noted in Coble et al. (2010), RMA moved away from fixed rate differentials and adopted variable coverage level differentials which depend on the crop and county-level base rate.[1] Empirical research concluded that the coverage level differentials should decrease as the base rate increases. The model specification used to estimate the implied coverage level differential is a function of coverage level (and its squared value), the county-level base rate at the 65% coverage level (and its squared value), and an interaction between the coverage level and the county-level rate at the 65% coverage level:

(1) $$Coverage\ Level\ Differential = \beta_0 + (\beta_1 \times coverage\ level) + (\beta_2 \times coverage\ level^2) + (\beta_3 \times rate_{65\%}) + (\beta_4 \times rate_{65\%}^2) + (\beta_5 \times coverage\ level \times rate_{65\%})$$

1.2.2 Trend-Adjusted APH

More recently another adjustment, the Trend-Adjusted APH (TA) option, has provided an additional mechanism to adjust historical yield experience for upward trending yields, resulting in an increase to the approved yield relative to the simple average. As stated in the overview of the Trend-Adjusted APH Standards Handbook, producers have an option to adjust yields in APH databases to reflect increases in yields through time in the county. Trend adjustments are made on each eligible yield within a qualifying APH database based on the county's historical yield trend. The actuarial documents provide the historical yield trend. The approved APH yield is calculated using trend-adjusted yields and any other applicable yields within the APH database.[2]

The trend adjustment has the same effect as increasing the coverage level elected. For example, if the trend adjustment increases the approved yield from 100 bushels per acre to 115 bushels per acre then the yield guarantee per acre at 65 percent coverage changes from 65 bushels per acre to approximately 75 bushels per acre. Therefore, the effective coverage level is 75 percent and the

[1] The recommendation of moving to a variable coverage level differential was also supported by Babcock, Hart, and Hayes (2004).
[2] FCIC-20220 (13-20220).

correct premium rate to charge should align with 75 percent coverage not the elected (nominal) 65 percent coverage level.

When introduced, the trend adjustment option posed a fundamental question, "If the effective coverage differs from the nominal coverage level, then how should the resulting loss experience relate to the actuarial system?" Ultimately, a fairly straightforward actuarial principle comes into play – adjustments must be made to insure the loss experience underlying the premium rates and the coverage offered must be consistent. This led to adjusting the historical loss experience for TA policies so that it reflected the effective coverage level rather than the nominal coverage level.

1.3 Remainder of the Report

The rest of the report is organized as follows. The second section addresses a number of issues associated with YE coverage level differentials. The third section examines how YE experience can be incorporated into the development of base premium rates. The fourth sections contains actuarial recommendations for YE. The fifth section lists sources cited in this report. The last two sections are appendices. Appendix A provides more detailed information in support of our recommendations regarding extrapolated coverage level differentials, while Appendix B provides tables reporting the data underlying figures shown in Appendix A.

2.0 The RMA's Proposed Approach for Effective Coverage Level Differentials

Under circumstances explained above, the YE provisions give a grower the option to modify the APH database in a way that increases the approved yield on a policy unit. Insuring a higher yield increases expected indemnities and requires an adjustment to premium rates in order to maintain actuarial soundness. In this section we summarize the approach proposed by the RMA for adjusting premium rates to account for higher expected indemnities on policy units making use of YE.

The RMA proposes to adjust premium rates for policies that utilize the YE provision in the same way that it currently adjusts rates for policies that utilize the TA option. The TA rate adjustment process is considered appropriate for YE rates because both TA and YE increase the yield guarantee relative to what it would be based on a simple average of historical yields (with or without yield plugs). The basic principle underlying the proposed method is that the same premium should be charged for a given yield guarantee on a policy unit no matter whether the guarantee is derived from a simple average of APH yields or from an average of yields with TA or YE.

The rate adjustment applicable for TA and proposed for YE is based on the relationship between the nominal and effective coverage levels for the insured policy unit. The nominal coverage level is the stated coverage level selected by the insured. The effective coverage level is given by:

$$(2.1)\quad Effective\ Coverage\ Level = Nominal\ Coverage\ Level \times \frac{YE\_APH}{SA\_APH}$$

where SA_APH is the simple average of yields in the APH database (or the average after yield plugs have been applied) and YE_APH is the average of yields in the APH database after low yields have been excluded under the YE provisions.

The YE procedure is illustrated by the example in Table 2.1. Here we show the year, county t-yield, 60% of the county t-yield, producer APH yield, APH with 60% yield plugs, and the APH with excluded yields. The APH with 60% plugs shows the incorporation of yield plugs into the producer's yield history. The yield plugs affect the APH yield in three years (2011, 2012, and 2013) and YE affects yields in 2011 and 2012. Assuming that the producer insures at the 75% (nominal) coverage level, the effective coverage level is given by:

$$(2)\quad Effective\ Coverage\ Level = Nominal\ Coverage\ Level \times \frac{YE_{APH}}{SA_{APH}} = 75\% \times \frac{108}{100} = 81\%$$

Table 2.1 Effects of Yield Exclusion on Approved Yield

Year	County T-yield	60% of T-yield	Producer APH	APH with 60% Plugs	APH w/ Excluded Yields
2005	96	58	110	110	110
2006	104	62	100	100	100
2007	104	62	88	88	88
2008	104	62	118	118	118
2009	106	64	111	111	111
2010	106	64	110	110	110
2011	119	71	55	71	Excluded
2012	119	71	20	71	Excluded
2013	119	71	57	71	71
2014	119	71	153	153	153
		Approved Yield:	**92**	**100**	**108**

Note that the Simple Average APH used in this calculation is the average or approved yield with yield plugs. This illustrates that the YE effective coverage level adjustment is applied after yield plugs.

Having obtained the effective coverage level with YE, the next step is to use coverage level differentials to obtain the premium rate. This would be a simple matter if all effective coverage levels were within the range of nominal coverage levels available and were on 5% rounded increments (for many crops 50% to 85% in 5% increments). However, two issues remain to be dealt with: (1) effective coverage levels that are between the lowest and highest nominal coverage levels available but that are not in 5% increments (in our example a coverage level of 81%) and (2) effective coverage levels above the highest available coverage level (in our example a coverage level above 85%).

The RMA proposes an approach for dealing with these issues which makes use of current coverage level differentials. For effective coverage levels that are within the range of available nominal coverage levels, simple linear interpolation would be used to derive a coverage level differential for the effective coverage level. Using CL to designate "coverage level," the formula for the linear interpolation is

(3) $$Effective\ CL\ Differential = Lower\ CL\ Differential + \left(\frac{(Upper\ CL\ Differential - Lower\ CL\ Differential)}{(Upper\ CL - Lower\ CL)} \times (Effective\ CL - Lower\ CL)\right).$$

where Lower CL is the coverage level obtained by rounding the effective coverage level down to the nearest available coverage level and Upper CL is the coverage level obtained by rounding the effective coverage level up to the nearest available coverage level. In our example, coverage level differentials for 80% nominal coverage and 85% nominal coverage would be used to obtain the coverage level differential for the 81% effective coverage level. Suppose that the coverage level differential for the 80% coverage level is 1.4 and the coverage level differential for the 85% coverage level is 1.5. The 81% effective coverage level differential would be derived as follows:

(4) $$Effective\ CL\ Differential = 1.4 + \left(\frac{(1.5 - 1.4)}{(0.85 - 0.80))} \times (0.81 - 0.80)\right) = 1.42.$$

where percentages have all been converted into equivalent decimals. The computed Effective Coverage Level Differential would be multiplied by the Base Premium Rate for 65% coverage to obtain the Base Premium Rate for the effective coverage level on the insured unit.

A similar approach is proposed for effective coverage levels that exceed the maximum nominal coverage level. In this case linear extrapolation (rather than interpolation) would be used. The extrapolation is based on the rate of change of coverage level differentials between the next to highest and highest available nominal coverage levels. The formula would be

(5) $$Effective\ CL\ Differential = Upper\ CL\ Differential + \left(\frac{(Upper\ CL\ Differential - Lower\ CL\ Differential)}{(Upper\ CL - Lower\ CL)} \times (Effective\ CL - Upper\ CL)\right)$$

where, the Upper CL is the highest available nominal coverage level and the Lower CL is next to highest available nominal coverage level.

In our example the coverage level differential for a 100% effective coverage level would be:

(6) $$Effective\ CL\ Differential = 1.5 + \left(\frac{(1.5-1.4)}{(0.85-0.80)} \times (1.00 - 0.85)\right) = 1.5 + \left(\frac{0.1}{0.05} \times 0.15\right) = 1.8$$

2.1 Coverage Level Differentials: Draft Report and Reviewer Response

This section reviews important aspects of the draft report as it relates to RMA's proposed approach for determining effective coverage level differentials. We also present pertinent concerns raised by the reviewers of the draft report.

2.1.1 Interpolation of Coverage Level Differentials

For effective coverage levels that are within the range of available nominal coverage levels, the draft report found the proposed interpolation method for deriving effective coverage level differentials to be reasonable and appropriate. Those who reviewed the draft of this document generally concurred with this view though one reviewer noted that the combination of the YE provision and the premium subsidy schedule (premium subsidy percentages generally decrease as the nominal coverage level increases) make it possible for two identical insureds to be charged different premiums for the same effective coverage level. This could occur, for example, if one of the insureds chooses a 75% coverage level and does not use the YE provision while the second insured selects a 70% nominal coverage level but uses the YE provision to obtain a 75% effective coverage. Since the premium subsidy percentage is higher for 70% coverage than for 75% coverage, the second insured would pay less for the same effective coverage. Sumaria Systems Inc. agrees with the point raised by this reviewer but notes that both the YE provision and the premium subsidy schedule are statutory.

2.1.2 Extrapolation of Coverage Level Differentials

In the draft report we generally supported RMA's proposal to use linear extrapolation procedures for determining premium rates on effective coverage levels above the maximum nominal coverage level. However, we also stated that the proposed linear extrapolation should be a short-term measure until data are available to evaluate alternative approaches. We also recommended that RMA consider limiting extrapolated marginal premium to be less than the marginal liability. That is, marginal premium rates should not exceed 100%. Finally, we also noted that high effective coverage levels could create incentives for behavioral responses (e.g., moral hazard and adverse selection) that would increase expected indemnities in ways not addressed by simply extrapolating coverage level differentials.

The issue that raised the most concern among reviewers of the draft document was the proposed linear extrapolation procedures for determining premium rates on effective coverage levels above the maximum nominal coverage level. Almost all of the reviewers argued that the relationship between effective coverage levels and premium rates is likely to be nonlinear. For example, one reviewer stated that "for most any well-behaved and commonly used yield distribution, and for most risk levels, the relationship [between effective coverage levels and premium rates] is convex (rates increase at an increasing rate)." The reviewers also noted that the extent of the convexity will depend on the variance of the yield distribution with greater convexity occurring in areas with lower yield risk. As the level of yield risk increases the relationship between effective coverage levels and premium rates becomes more linear and, in extreme cases, can even become concave (premium rates increasing at a decreasing rate).

The problem, of course, is that the yield distribution for the insured unit is unobservable so errors are likely to occur with any assumed relationship between effective coverage levels and premium rates. Furthermore, in the absence of data on higher effective coverage levels, there is no way to empirically investigate which extrapolation procedure is likely to minimize these estimation errors. This is evidenced by the fact that while several of the reviewers criticized the proposed linear extrapolation procedure, they each proposed a different alternative. One reviewer suggested a quadratic or cubic extrapolation procedure whereby whatever quadratic (cubic) curvature exists in the premium rate differentials between the three (four) highest coverage levels is extrapolated out to effective coverage levels that exceed the maximum nominal coverage level available. Another reviewer suggested an estimation procedure that is computationally different but also relies upon the curvature in the current coverage level premium rate differentials to extrapolate to higher coverage levels.

While we agree that the concern about convexity is worthy of examination we do not agree with these proposed solutions. These approaches are simply extrapolations that take curvature of the current coverage level premium rate differentials into account. They don't offer any insight into whether this curvature extends *in the systematic way their approaches assume* to effective coverage levels well above the current maximum. Furthermore, we would point out that if the RMA believed that the current mathematical formulas used to develop premium rate differentials were valid at coverage levels much higher than those on which the rate formulas were based then they could simply use the current formulas. No approximation would be needed.

Other reviewers recommended basing extrapolated coverage level premium rate differentials on assumed yield distributions. Among the yield distributions proposed were the Weibull, Beta, and truncated Normal distributions. While these analyses provide interesting insights, it is important to remember that we cannot observe the actual yield distribution. This is, of course, why *RMA's yield risk rating procedures are not based on any distributional assumptions*. If we knew the actual yield distribution for each combination of risk classification factors (e.g., crop, county, type, practice), experience-based premium rating would not be required – premium rating would simply be a matter of integrating under the known distribution at the effective coverage level.

In Appendix A, we use one reviewer's analysis, along with data on exclusion eligibility and base premium rates, to evaluate the extent of rate errors due to linear extrapolation of coverage level premium rate differentials. This analysis confirms that the number of yields excluded will generally be low in low risk counties. These are the counties with low premium rates where the analyses provided by reviewers indicated that rate errors would be large if YE were heavily used resulting in high effective coverage levels. Conversely, we show that a large number of yields will potentially be excluded in high risk counties with high premium rates. In the analyses provided by reviewers, the linear extrapolation procedures proposed by RMA performed reasonably well in high risk counties. One reviewer's analysis using two probability distributions, the Beta and truncated Normal, produced ambiguous results regarding whether approximation error due to linear interpolation would be positive or negative in high risk counties. Even if the error is negative, meaning rates are too low, the magnitude of the estimated error was small.

Our conclusion, based on our own analysis and that provided by the reviewers, is that the extent of rate error due to linear extrapolation of coverage level premium rate differentials is likely small in many counties because it has its greatest potential effect in low risk counties where few yields are likely to be excluded and has a relatively small effect in high risk counties where the number of yields excluded is likely to be much larger. However, in response to the concerns raised by the reviewers, we have revised our previous recommendation on extrapolation of coverage level premium rate differentials. We now suggest that RMA perform a new analysis of these differentials as soon as is practicable using its current procedure. Since this approach can be used to re-compute loss experience from several years at coverage levels other than the coverage actually insured, it appears straightforward to go ahead and do this analysis. However, it may still be advisable to revisit the issue in a few years.

2.1.3 Capping Marginal Premium Rates

In the draft version of this document we recommended that RMA consider marginal premium rate caps such that the additional premium for any coverage interval could not exceed the additional liability. One reviewer stated that such a restriction was unnecessary because a marginal premium in excess of marginal liability would not occur with the proposed linear extrapolation procedure. Another reviewer argued that the marginal premium should be capped at a level that is less than the marginal liability because there is always some probability that a loss may not occur in the marginal layer of coverage.

In fact, it is possible for marginal premium to exceed marginal liability (marginal premium rates in excess of 100%) with the linear extrapolation procedure proposed by RMA. To see this, consider an example for non-irrigated cotton in Martin County, Texas where the effective coverage level increases from 85% to 90%. The 80% Coverage Level Differential is 1.15 and the 85% Coverage Level Differential is 1.20. Using the proposed linear extrapolation, the 90% Coverage Level Differential would be

(7) $$90\%\ Coverage\ Level\ Differential = 1.20 + \left(\frac{(1.20-1.15)}{(0.85-0.80)} \times (0.90-0.85)\right) = 1.25$$

The liability per acre for 85% coverage would be equal to the product of approved yield, projected price, and 85%. Likewise the liability per acre for 90% coverage would be equal to the product of the approved yield, projected price, and 90%. For simplicity, assume a projected price of $1.00 per unit of production so the liability per acre for 85% coverage is equal to 85% of the approved yield and the liability per acre for 90% coverage is equal to 90% of the approved yield.

Assuming that the approved yield is equal to the reference yield, the 65% base rate is the sum of the reference rate and the fixed rate. For non-irrigated cotton in this county the reference rate is 0.5440 and the fixed rate is 0.0610, so the 65% base rate would be 0.6050. The premium per acre for 85% coverage would be equal to the product of liability, the base rate and the 85% coverage level differential or

(8) $$85\%\ Coverage\ Premium\ per\ Acre = 85\% \times Approved\ Yield \times 0.6050 \times 1.20 = 0.6171 \times Approved\ Yield$$

Likewise the premium per acre for 90% coverage would be

(9) $$90\%\ Coverage\ Premium\ per\ Acre = 90\% \times Approved\ Yield \times 0.6050 \times 1.25 = 0.6806 \times Approved\ Yield$$

In this example going from 85% to 90% coverage increases liability by 5% of Approved Yield but increases premium by 6.35% (0.6806 – 0.6171) of Approved Yield, implying a marginal premium rate that exceeds 100%.

We don't disagree with the reviewer who argued that, in principle, marginal premium rates should be capped at a level that is less than 100% since, even for very high effective coverage levels, there is always some probability that a loss may not occur in the marginal layer of coverage. However, we would suggest that this theoretical point cannot be practically implemented without knowing the yield distribution on the insured unit. Since RMA cannot observe yield distributions on insured units but may (due to the YE provision) be required to determine premium rates for coverage levels significantly above the current maximum nominal coverage level, a marginal premium rate cap of 100% seems a reasonable restriction to avoid allowing marginal premium to exceed marginal liability.

2.1.4 Behavioral Load

In our draft report we noted that a behavioral response might occur due to the potential for high effective coverage with the YE provision. We recommended that RMA evaluate this issue after collecting two years of YE experience.

One reviewer noted that the YE provision could increase incentives for both moral hazard and adverse selection. For the unit-level federal crop insurance products, the primary mechanism for controlling moral hazard is the deductible (100% minus the coverage level). If the YE provision causes the effective coverage level to increase, the effective deductible will decrease. Currently, the maximum coverage level is 85% so the minimum allowable deductible is 15%. With the YE provision it will be possible to have effective coverage levels higher than 85% (effective deductible less than 15%). It is even possible that effective coverage levels could exceed 100% so the effective deductible will be negative. The obvious concern is that lower (or even negative) deductibles will create increased incentives for insured growers to engage in moral hazard behaviors.[3]

The reviewer also argued that the YE provision could exacerbate existing adverse selection problems because, within a given county that qualifies for one or more years of YE, riskier growers are more likely to choose to exclude yields.[4]

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[3] Note that this definition of deductible, as used in crop insurance, expresses the loss borne by the insured before an indemnity is paid as a percentage of expected revenue or expected yield. Given this definition a negative deductible is quite possible. If the deductible were expressed with reference to the maximum revenue or yield it could only be negative if the amount of coverage exceeded the maximum possible revenue or yield. Our point is that a zero or negative deductible as commonly defined in crop insurance does not mean that the insurer has assumed all risk and that the insured bears no risk.

[4] The reviewer also argued that the Yield Exclusion provision would likely change the riskiness of the book of business for Approved Insurance Providers because higher risk counties will qualify for yield exclusion more often than lower risk counties. Furthermore, Yield Exclusion induced increases in effective coverage levels would likely increase claim frequency and thus loss adjustment expenses. We don't disagree with either of these points but both are beyond the scope of issues that Sumaria Systems Inc. was asked to review.

We agree with the reviewer that these are legitimate concerns, which is why we recommended that RMA evaluate this issue after two years of data are available. Our understanding is that the reviewer did not disagree with our recommendation *per se* but was instead arguing that some rate adjustment should be employed immediately in anticipation of YE induced increases in moral hazard and adverse selection problems.

RMA currently uses a proportional unit residual factor to partially address moral hazard and adverse selection. The unit residual factor is typically set at 1.00 for lower coverage levels. At higher coverage levels the unit residual factor may or may not exceed 1.00. If it exceeds 1.00 it also increases as the coverage level increases. If the unit residual factor is greater than 1.00 for 85% coverage, then using the 85% coverage unit residual factor for effective coverage levels above 85% would generate a higher load in absolute terms (because the proportional load would be applied to a higher underlying premium rate). With the YE provision, the question is whether the proportional unit residual factor should continue increasing as effective coverage levels increase beyond the current 85% maximum (that is, should there be a positively sloped unit residual factor extrapolation). If so, a follow-up question is whether the positively sloped extrapolation should be linear, convex, or concave.

We agree with the reviewer that the YE provision will lead to higher effective coverage levels that may exacerbate moral hazard and/or adverse selection problems. Given this, some positively sloped unit residual factor extrapolation may be appropriate. However, until experience data are available that can be used to analyze these issues, we have no basis for making recommendations about how such premium loads should be constructed.

3.0 The RMA's Proposed Approach for Actuarial Adjustments

The rating process for APH-based insurance plans is built around historical loss experience. However a number of adjustments are made to the actual loss experience (see Coble et al., 2010). Many of these adjustments (e.g., the adjustment for converting revenue insurance indemnities to a yield insurance basis) are unaffected by the introduction of the YE provision and will not be discussed here.

Our principle concern is the adjustment of the yield experience to the common coverage level used in the development of base rates. Prior to the introduction of the YE provision, nominal and effective coverage levels are equivalent with the exception of nominal coverage levels based on trend-adjusted yields. The current process adjusts trend-adjusted yield nominal coverage via a two-step process. First, the experience data from trend-adjusted yield policies is translated into what it would have been had the grower not chosen the trend-adjustment option. This is done as follows:

Adjusted APH Yield = APH including yield substitutions but not trend-adjustment

*Restated Liability = Adjusted APH Yield * Nominal Coverage Level*

*Restated Indemnity = Indemnity – (Effective Coverage Level – Nominal Coverage Level) * Adjusted APH Yield*

For example, if nominal coverage is 50% but effective coverage due to trend adjustment is 70%, liability and indemnity at the individual record level are adjusted to the nominal 50% coverage level. In particular, losses between the nominal and effective coverage levels are excluded from the individual record data.

Adjustment to the common 65% coverage level then proceeds as usual: Liability is adjusted to the common coverage level by multiplying by 65% / nominal coverage. Indemnity is adjusted in one of two ways, depending on whether the coverage level is higher than or lower than 65%. For coverage levels in excess of 65%, indemnity is adjusted downward to the 65% coverage level. As discussed in Coble, et al., (2010), this procedure is exact because it requires only the removal of indemnities in excess of 65% coverage. That is, all of the indemnities that would have been paid had the grower selected 65% coverage are already in the loss records. For coverage levels less than 65%, however, a more complicated estimation method is required because detailed information on indemnities for production ratios between the actual coverage level and the common coverage level is not available. RMA uses a reasonable procedure to estimate the additional indemnity between the actual coverage level and the common coverage level, but out of necessity the result is an estimate.

3.1 Actuarial Adjustments: Draft Report and Reviewer Response

In the draft report we noted that the initial adjustment at the individual record level will always be downward, because both the trend-adjustment option and the YE exclusion provision will only be selected if they afford the grower the opportunity to select greater coverage. So long as the nominal coverage level is at least 65% (and therefore the effective coverage level even higher), the two-step process will result in an exact adjustment of the data to the common coverage level. However, when the nominal coverage level is less than 65%, adjusting the individual record downward to the nominal coverage level *loses actual indemnity information that must then be recreated through estimation during the standard adjustment process.*

We recommended that RMA instead adjust individual loss data for effective coverage levels in excess of 65% directly to the common 65% coverage level. This step could be used for all records where the effective coverage level is in excess of 65% due to the policy-holder exercising either the trend-adjustment option or the YE provision. For records with effective coverage levels in excess of the nominal coverage level but less than 65%, we recommended that the data remain at the effective coverage level, so as to preserve as much information as possible. A few examples may make our recommendations clearer:

1. Nominal coverage = 70%, Effective Coverage Level (ECL) = 150%.

   *Liability = 70% * YE APH = 150% * Adjusted APH Yield*
   *Adjusted Liability = 65% * APH Yield = Liability * 65% / 150%*
   *Adjusted Indemnity = Indemnity – (150% - 65%) * Adjusted APH Yield*

   Data enters at 65% coverage level. Conversion to common coverage level is exact.

2. Nominal coverage = 50%, Effective Coverage Level (ECL) = 80%.

   *Liability = 50% * YE APH = 80% * Adjusted APH Yield*
   *Adjusted Liability = 65% * APH Yield = Liability * 65% / 80%*
   *Adjusted Indemnity = Indemnity – (80% - 65%) * Adjusted APH Yield*

   Data enters at 65% coverage level. Conversion to common coverage level is exact.

3. Nominal coverage = 50%, Effective Coverage Level (ECL) = 60%.

   *Liability = 50% * YE APH = 60% * Adjusted APH Yield*
   Adjusted Liability = Liability
   Adjusted Indemnity = Indemnity

   Data enters at 60% coverage level. Conversion to common coverage level is exact to the 60% coverage level, estimated between 60% and 65% coverage.

None of the reviewers expressed any concerns with these recommendations regarding actuarial adjustments for YE policies.

4.0 Recommendations

Based on our initial assessment of the procedures proposed by RMA and the comments provided by reviewers of our draft report, our recommendations regarding actuarial procedures for YE are as follows:

Recommendation 1

We recommend that the RMA follow the approach they have proposed and that we have described in computing effective coverage levels for policy units making use of Yield Exclusion in determining the yield guarantee.

Recommendation 2

We recommend that the RMA adopt the proposed procedures for deriving effective coverage level differentials and premium rates for policy units making use of Yield Exclusion.

Recommendation 3

We recommend that the RMA evaluate the feasibility of incorporating marginal premium rate caps such that the additional premium for any coverage interval cannot exceed the increase in liability.

Recommendation 4

We recommend that, at least for counties with base rates below 5%, RMA utilize the approach that has been used in the past to re-estimate coverage level relativities. This approach estimates losses at coverage levels other than that for which insurance was actually purchased, without imposing distributional assumptions. This should be done as soon as is practicable. We also recommend that, after two years of Yield Exclusion experience data have been collected, RMA analyze the data for evidence of behavioral responses to high effective coverage levels. Prior to this data becoming available, RMA might consider some extrapolation of the unit residual factor.[5]

Recommendation 5

We recommend that the RMA adjust experience at the individual record level to the smaller of the 65% common coverage level or the effective coverage level prior to compilation in county loss experience data, thus preserving the actual indemnity experience in the base ratemaking process as much as possible.

Recommendation 6

We recommend that the RMA continue its current methods for adjusting compiled data at the county loss experience data level to the 65% common coverage level.

5.0 References Cited

Babcock, B.A., C. E. Hart, and D. J. Hayes. "Actuarial Fairness of Crop Insurance Rates with Constant Rate Relativities." *American Journal of Agricultural Economics*, 86(2004):563-575.

[5] Recommendation 4 has been revised from the draft version in response to reviewer comments. We are now recommending coverage level relativities be re-estimated as soon as possible and that the analysis extend beyond 85% coverage into the range relevant for the APH YE. Additionally, we have modified recommendation 4 to suggest that it would be reasonable for RMA to consider extrapolating the residual unit factor until experience data can be analyzed. However, we have no basis to suggest what form this extrapolation might take.

Coble, K.H., T.O. Knight, B.K. Goodwin, M.F. Miller, and R.M. Rejesus. “A Comprehensive Review of the RMA APH and COMBO Rating Methodology: Final Report.” Report prepared by Sumaria Systems for the USDA-Risk Management Agency, March 15, 2010.

Coble, K.H., M.F. Miller, R.M. Rejesus, B.K. Goodwin, R. Boyles, and T.O. Knight, “Methodology Analysis for Weighting of Historical Experience – Implementation Report” A report prepared for the USDA Risk Management Agency, September 5, 2011.

Appendix A

In this appendix we present analysis of the concerns raised by reviewers regarding the proposed linear extrapolation of coverage level premium rate differentials. Most of the reviewers argued that using linear extrapolation to derive premium rates for coverage levels above the current maximum nominal coverage level will lead to errors in premium rates because the rate differentials should be convex rather than linear. The information used in our analysis includes: (1) county level base premium rates for corn and cotton, (2) county level information on crop years eligible for YE, and (3) one reviewer's simulated relationships between effective coverage levels and linear extrapolation error.

It is clear that the effect of YE on effective coverage levels and premium rates depends, in part, upon the number of years of yields eligible for exclusion and the number of years actually excluded. To address the first issue, we obtained data on crop years eligible for YE (excludible years) from the RMA. These are the data underlying the maps posted on the RMA website [http://www.rma.usda.gov/news/currentissues/aph/index.html]. These data span the 19 year period from 1995-2013; however in this analysis we use the data for the most recent 10 years, 2004-2013. For non-irrigated corn, the percent of counties with each number of excludible years is shown by the orange bars in Figure A.1, which indicates that approximately 37% of corn counties had no excludible years in the past 10, that approximately 26% of counties had 1 excludible year, and that approximately 15% of counties had 2 excludible years. The percentage of counties continues to decline as the number of excludible years increases from 3-7 and no county had more than 7 excludible years. The blue bars in Figure A.1 show the average base premium rate for counties with each number of excludible years. The average premium rates for counties with zero and 1 excludible years are approximately 8.7% and 11.7%, respectively. Average rates for counties with 2-7 excludible years range from approximately 17% to 26%. To summarize, the data in Figure A.1 show that more than 60% of non-irrigated corn counties had zero or 1 excludible years, and that those counties have average base premium rates in the 10% range. A decreasing percentage of counties had 2 or more excludible years and those counties have average base premium rates near or above 20%. The main point is that a large percentage of non-irrigated corn counties have 0-1 excludible years and those counties have average premium rates in the 10% range. Counties with more excludible years have much higher premium rates on average.

Figure A.2 summarizes the same information as Figure A.1, but for non-irrigated cotton. The patterns revealed are the same. Approximately 66% of non-irrigated cotton counties had zero or 1 excludible years. These counties have average base premium rates in the 13% to 15% range. Average premium rates for non-irrigated cotton counties with 2 or more excludible years range from approximately 21% to 52%.

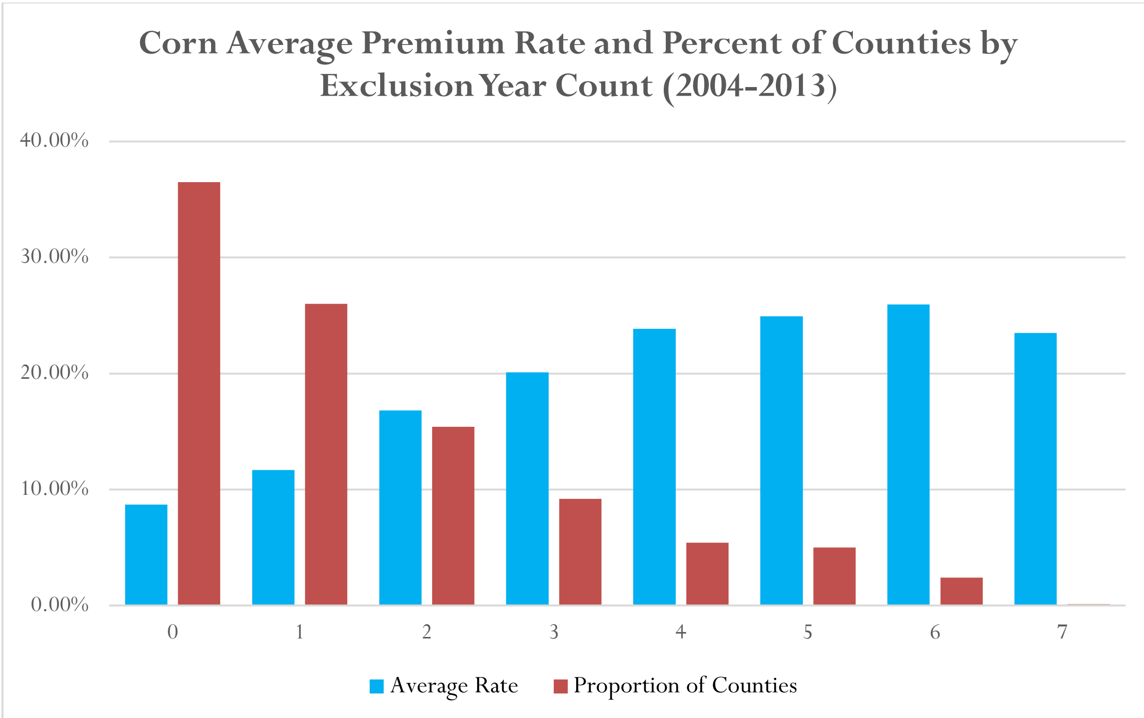

Figure A.1 Non-irrigated corn average base premium rates and percentage of counties by number of years eligible for yield exclusion.

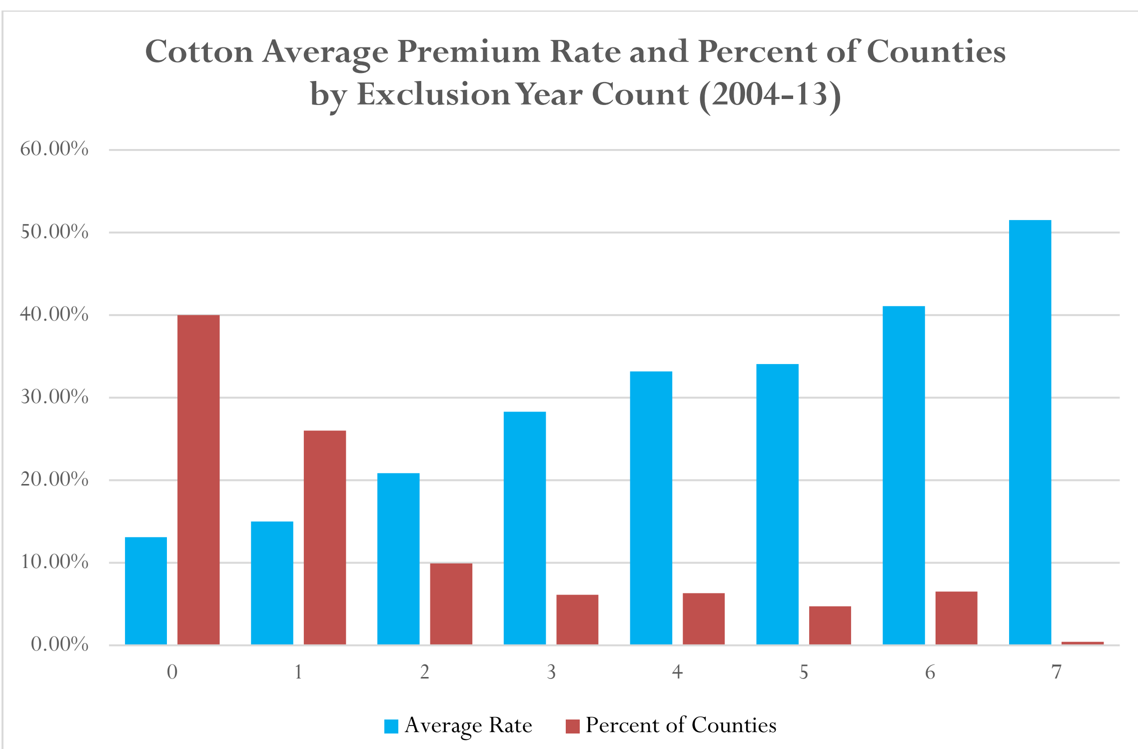

Figure A.2 Non-irrigated cotton average base premium rates and percentage of counties by number of years eligible for yield exclusion.

To further examine YE eligibility and the effects of exclusion on effective coverage levels, figures A.3 and A.4 present, *for counties with base premium rates below 10%*, the percentages of counties with each number of excludible years observed in the data. For non-irrigated corn, Figure A.3 shows that approximately 60% of such counties had no excludible years in the period 2004-2013. Approximately 32% of counties had 1 excludible year in the same period. Roughly 8% of these low risk non-irrigated corn counties had from 2 to 5 excludible years in the 10 year period. Figure A.4 shows that approximately 67% of low risk non-irrigated cotton counties had no excludible years in the 10 year period, approximately 28% had 1 excludible year, and approximately 4% of counties had 2 excludible years.

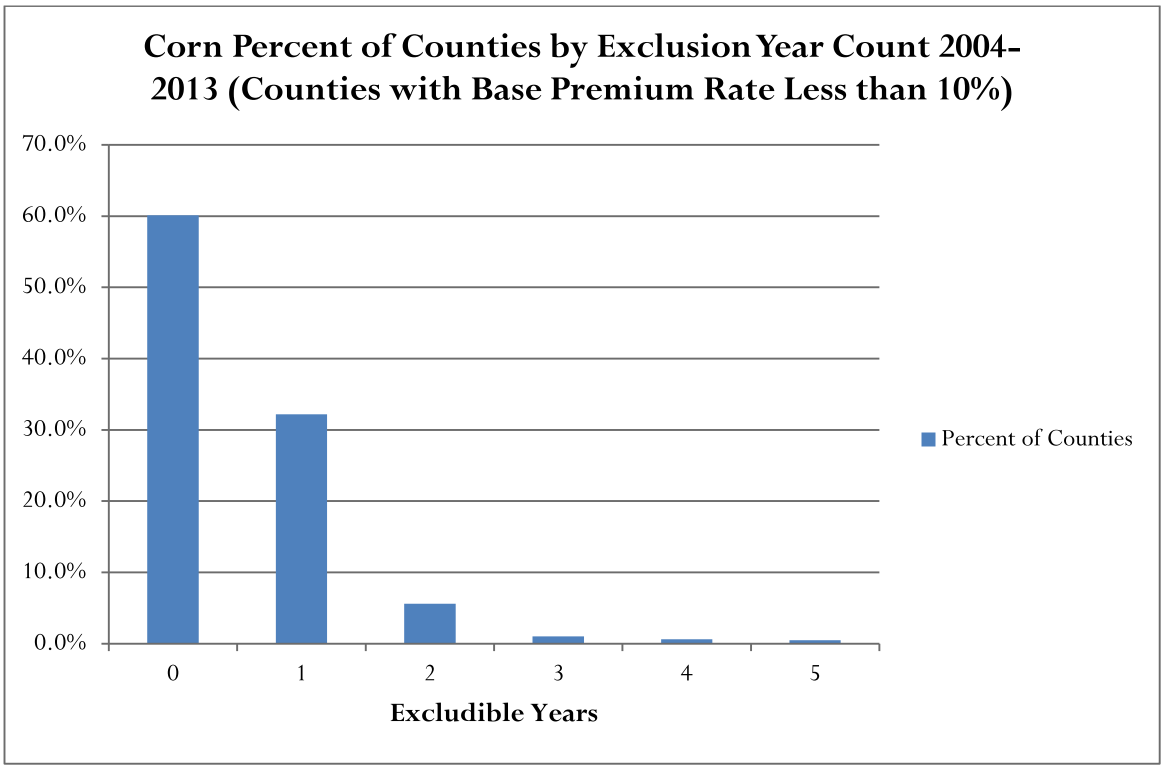

Figure A.3 Percentage of low risk (premium rate < 10%) non-irrigated corn counties by number of years eligible for yield exclusion.

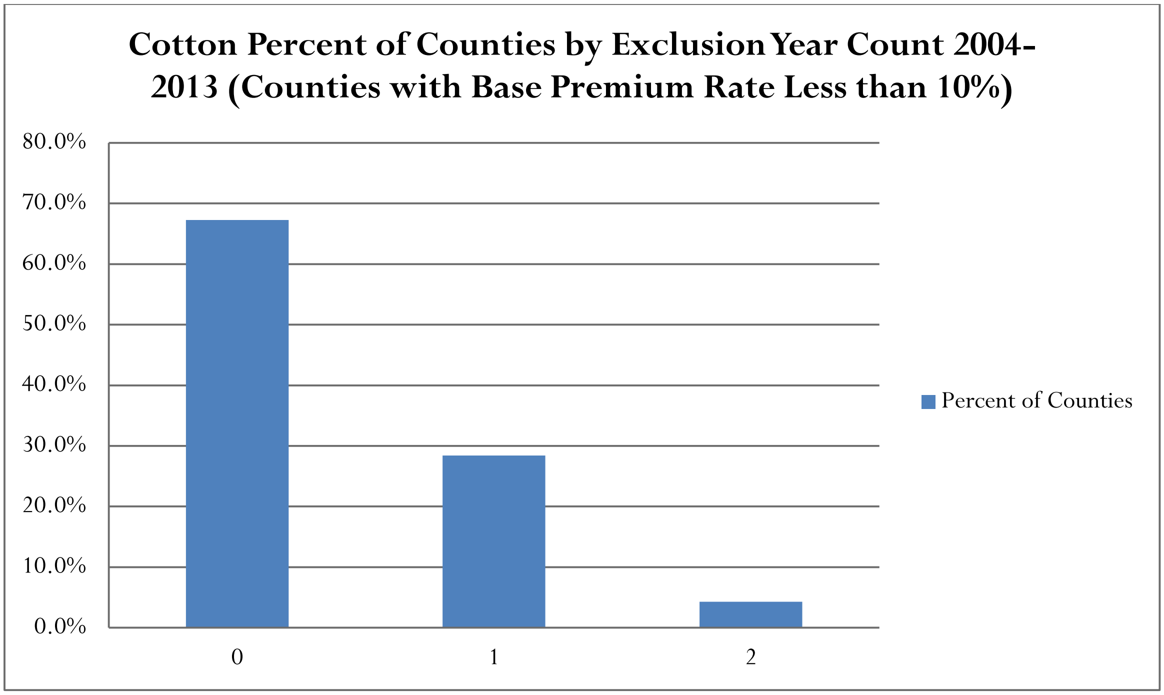

Figure A.4 Percentage of low risk (premium rate < 10%) non-irrigated cotton counties by number of years eligible for yield exclusion.

Since most low risk corn and cotton counties had either zero or 1 excludible years, and since YE has no effect with zero exclusion years, an important question is: "What is the potential effect of 1 excludible year." In order to address this question we first examine the effect of 1 excluded year on effective coverage levels. Figure A.5 shows effective coverage levels for a 10 year yield history with 1 yield excluded and Figure A.6 presents a similar summary for a 5 year yield history with 1 yield excluded. These figures assume a T-yield of 100 for the excluded year and further assume that the actual yield for the excluded year is below 60 such that a yield plug of 60 is applied for the excluded year. What these figures show is that 1 excluded year only results in effective coverage significantly above 85%, where use of the extrapolation procedure begins, if the nominal coverage level is above 75%. Even with 85% nominal coverage the effective coverage level is approximately 92% for a 10-year yield history when the average yield for non-excluded years is 200 (note that this is 200% of the t-yield for the excluded year) and is approximately 100% for a 5-year APH yield history with 1 excluded year and an average yield for non-excluded years of 200. These results indicate that two conditions must exist in order for 1 excluded yield to increase effective coverage to a level of 90% to 100%. These conditions are: (1) high nominal coverage level above 75% and (2) average yield for non-excluded years much higher than the exclusion year yield (with plug if applicable). Next we examine how these results translate into potential rate errors due to linear extrapolation.

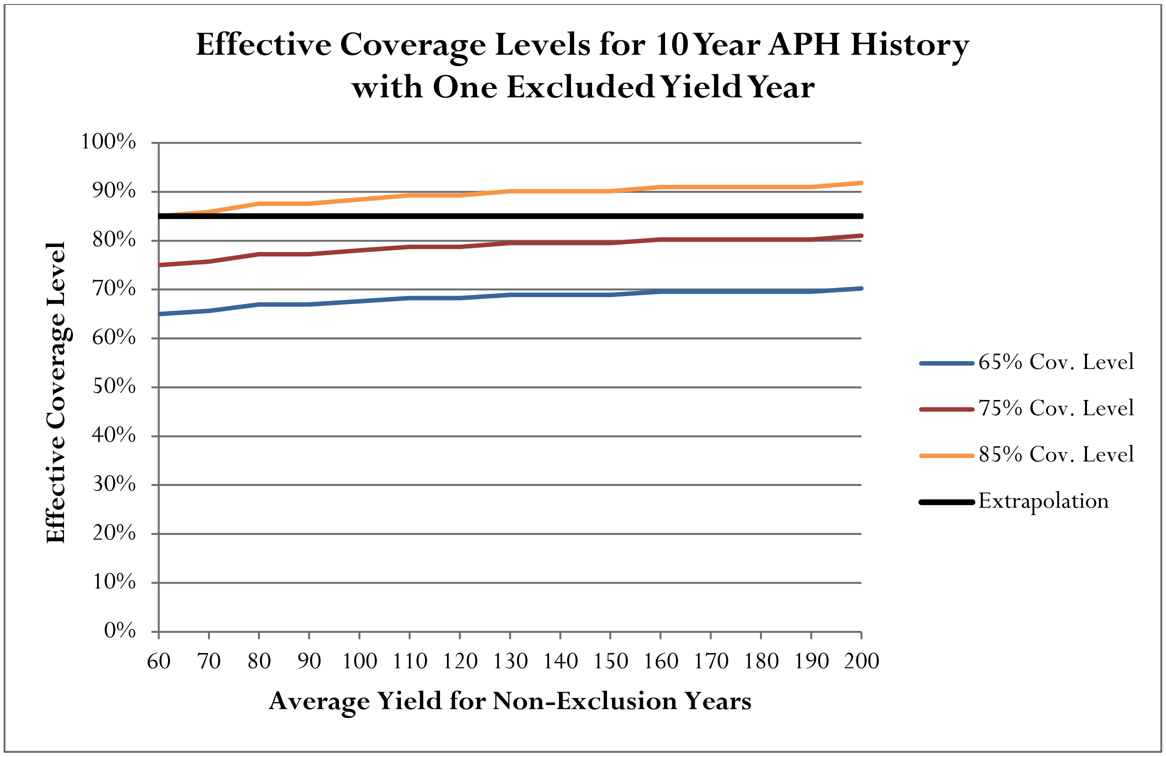

Figure A.5 Analysis of effective coverage levels for a producer with a 10-year yield history and one excluded year with yield below the county T-yield.

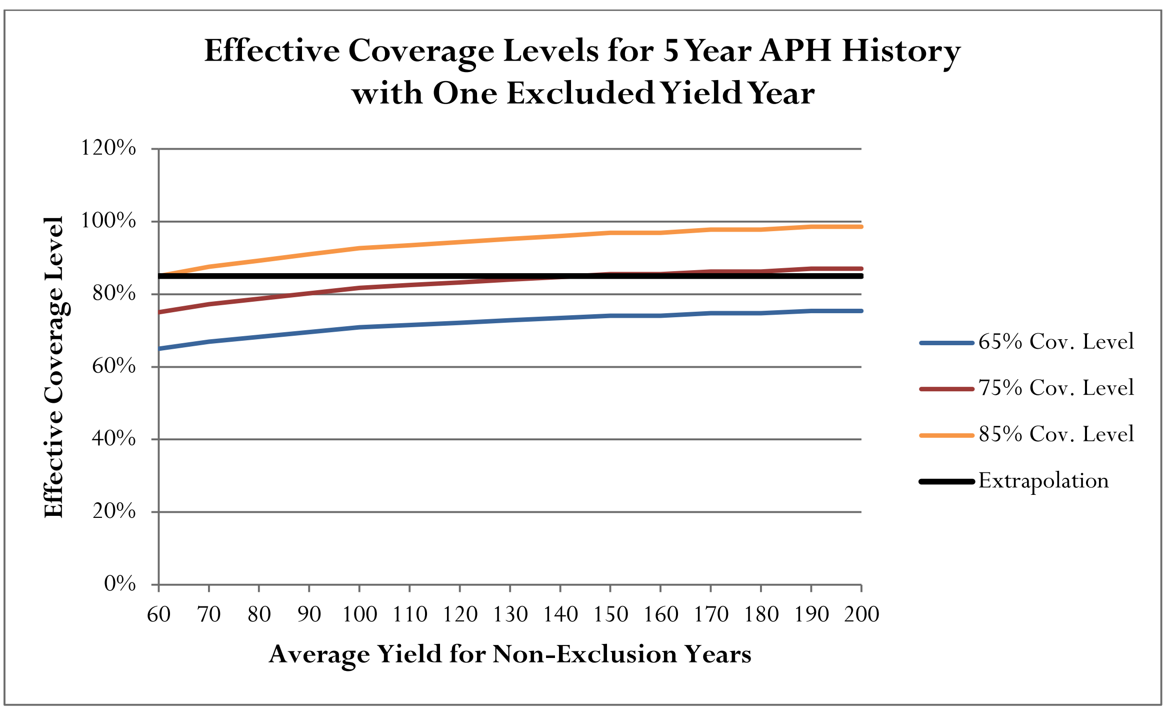

Figure A.6 Analysis of effective coverage levels for a producer with a 5-year yield history and one excluded year with yield below the county T-yield.

Figures A.7 and A.8 were extracted from the review provided by AgRisk Management (Bruce Babcock). These figures show the estimated error due to linear extrapolation for counties with premium rates ranging from 1% (0.01) to 30% (0.30). The results in Figure A.7 were estimated using a truncated normal distribution and those in Figure A.8 were estimated using a Beta distribution. Results for the two distributions are consistent in indicating that rates derived through linear extrapolation exhibit negative extrapolation error for counties with premium rates below 10%. The results are ambiguous for counties with premium rates of 10% or higher. The truncated normal distribution indicates almost no rate error for a premium rate of 30%, very small negative error for a premium rate of 20% and slightly larger negative error for a premium rate of 10%. The Beta distribution indicates modest positive rate errors for premium rates of 20% and 30% and almost no error for counties with a base premium rate of 10%.

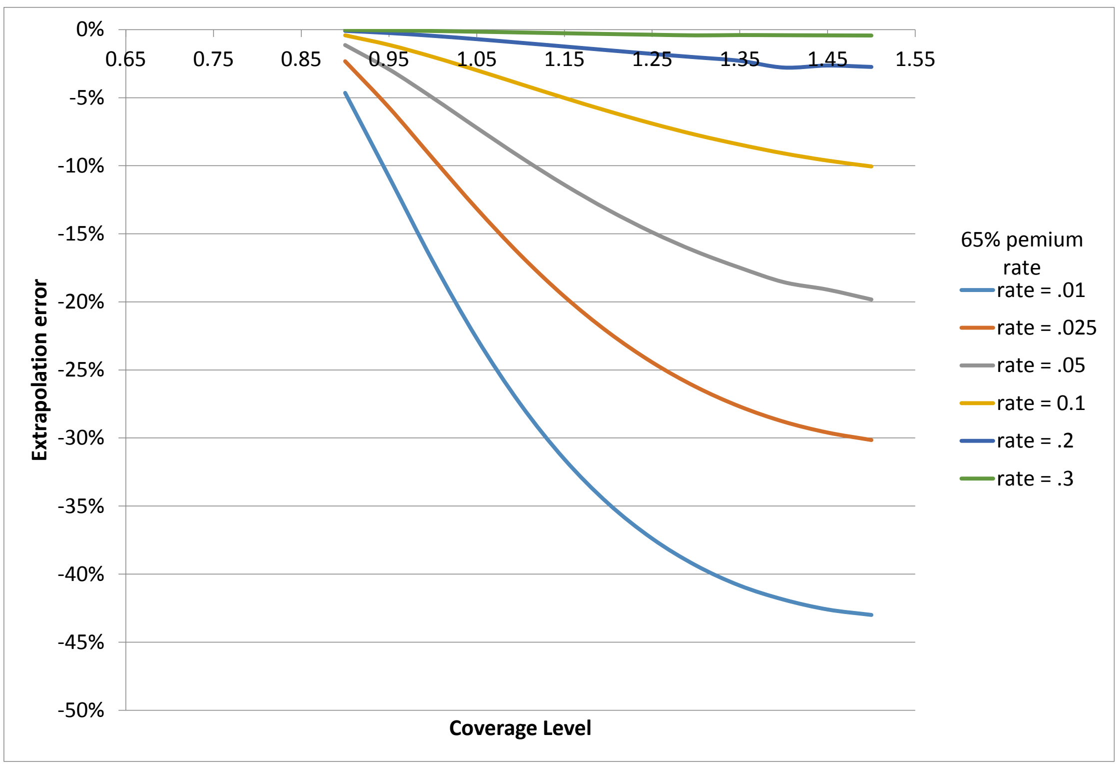

Figure A.7 Linear extrapolation errors assuming a truncated Normal yield distribution (from Babcock's reviewer report).

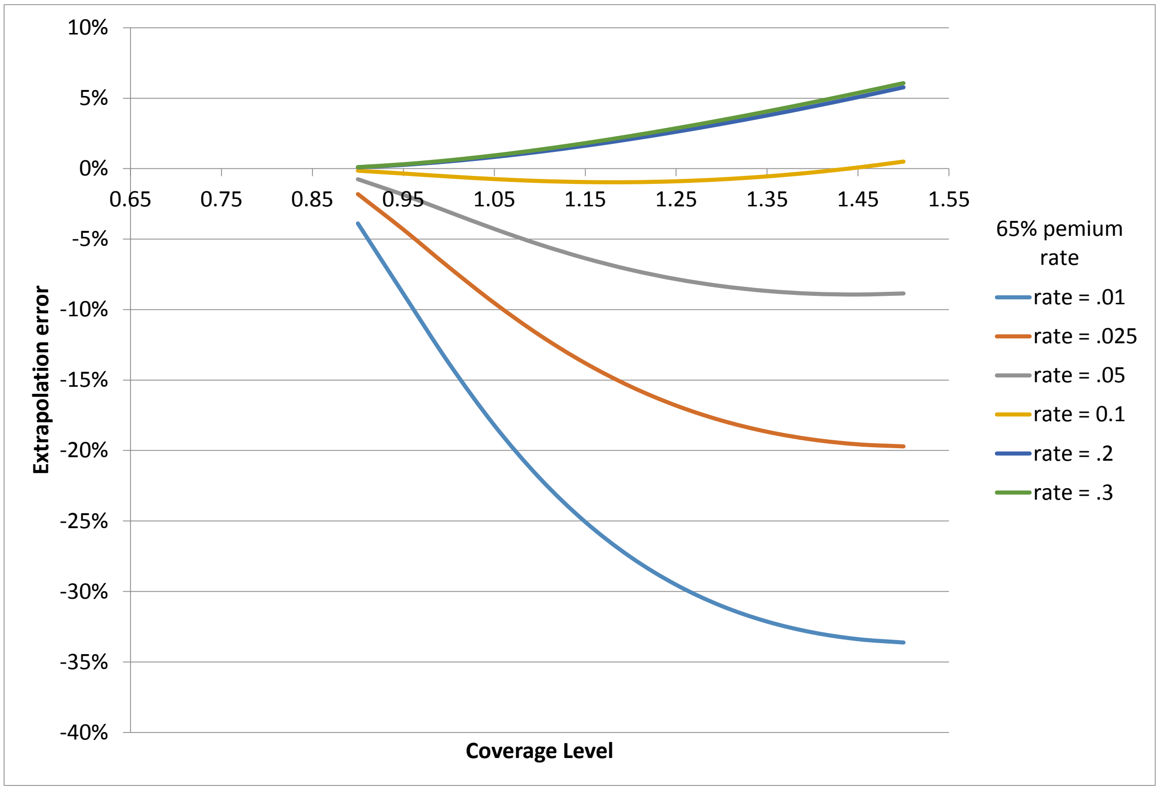

Figure A.7 Linear extrapolation errors for the Beta distribution (from Babcock's reviewer report).

Given the ambiguities in the results for the two distributions with rates of 10% or higher, and the relatively small magnitude of estimated error at these premium rates for both distributions, we would interpret these results as supporting the use of linear extrapolation for counties with base premium rates at or above 10%. Importantly, as Figures A.1 and A.2 show, these high risk areas are where more years are eligible for exclusion and hence where YE will have its largest influence on effective coverage levels.

Estimated linear extrapolation errors for counties with rates of 5%, 2.5%, and 1% depend upon the effective coverage level. While figures A.7 and A.8 show effective coverage levels ranging as high as 155%, our results above indicate that the relevant range given 1 excluded yield is up to 90% for a 10 year yield history and 100% for a 5 year yield history. Consider a 5 year yield history with 100% effective coverage and a 5% nominal premium rate. Figures A.7 and A.8 indicate estimated extrapolation errors of approximately negative 5% and negative 2.5% for this case. Thus, based on the information from our analysis of effective coverage levels and the reviewer's estimates of extrapolation error (with the assumed yield distributions), the error is very small for a 5% base rate, a relatively short 5 year yield history, 1 excluded year, and an average yield for non-excluded yields of 200% of the T-yield. Estimated extrapolation errors for premium rates of 2.5% and 1% are negative and considerably larger in magnitude.

The review provided by AgRisk Management recommended using an assumed truncated normal yield distribution to extrapolate coverage level premium rate differentials. The review noted that the RMA has the required draws from this distribution available due to its use in Revenue Protection rating. However, as is apparent from figures A.7 and A.8, different distributions produce significantly different results. And as we have noted earlier there is certainly no consensus on an appropriate distribution for the wide range of crops and regions for which the RMA has to produce rates. One could make different distributional assumptions and average them, but we would suggest that RMA instead continue its non-parametric approach.

Based on all of the above, we recommend that, at least for counties with base rates below 5%, RMA utilize the approach that has been used in the past to re-estimate coverage level relativities. This approach estimates losses at coverage levels other than that for which insurance was actually purchased, without imposing distributional assumptions. To date the process has been used up to the 85% coverage level. Conceptually, we see no reason not to take it to higher levels as needed to implement YE.