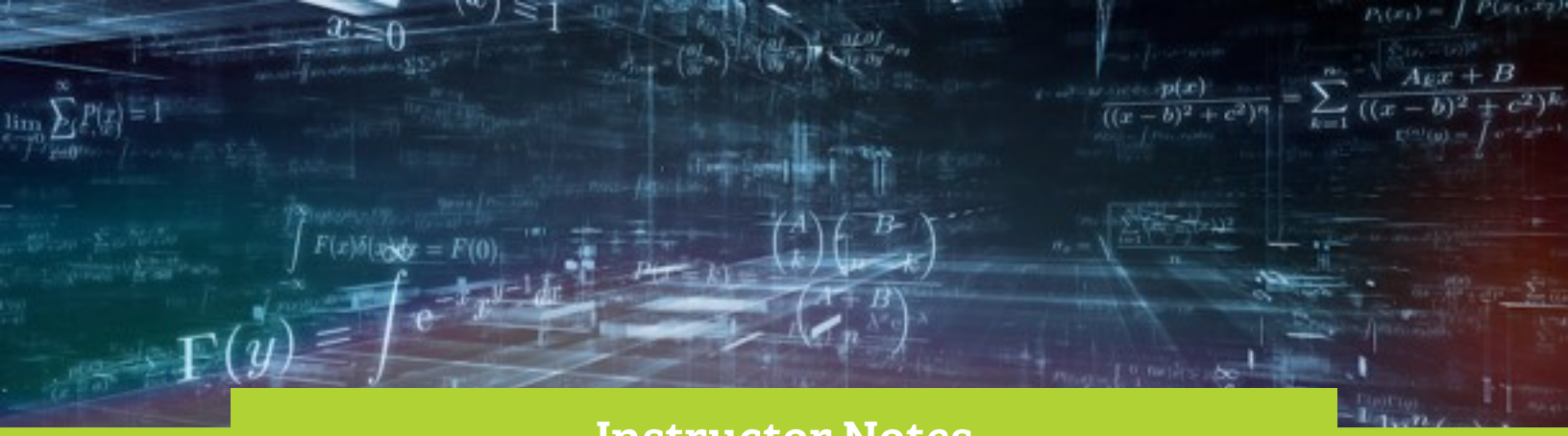
Basic Training Scenario

Federal Crop Insurance Corporation

Instructor's Guide

A program of The Actuarial Foundation

Modeling The Future Challenge



Instructor Notes

This Basic Training scenario is provided to help connect your students to the real-world mathematics used by actuaries and other risk-management professionals when creating insurance policies and exploring how to otherwise manage and mitigate potential risks.

Basic Training scenarios provide a set of entry level questions to guide your students through a series of fundamental concepts related to insurance and risk management. In each Basic Training scenario, students are provided an initial setup in which they will learn information about the scenario and respond to questions getting progressively more complex. These scenarios take a layered approach to engaging students. The first questions are the most simple, and we continue to add additional data and complexity to help them advanced through the concepts.

Basic Training Scenario Files:

- **Instructor MAIN** – this file provides the scenario description, questions, and information that your students will see in their worksheet, but also provides the answers and descriptions to each question for easy reference.
- **Student Workbook** – this file includes the scenario description along with the questions for students with some space to work out the answers. These are worksheets that can be handed out to your students to work through answers after you have introduced the scenario to them.
- **Slides** – this file is a set of slides that instructors can go through with their students to help introduce the concepts. If you would like to work through the activity as a group you can use the slides and stop to let the students answer the questions along the way. Slides also provide instructor notes to help in working through the scenario with your students.

Educational Concepts in this Scenario:

- Calculating expected values
- Mean values, standard deviations
- Basic probabilities
- Mathematical logic
- Critical thinking & problem solving
- Applied Probability & Statistics
- Insurance basics, deductibles, and premiums.

Scenario Introduction

The Federal Crop Insurance Corporation (FCIC) helps the American agricultural industry by providing insurance policies to farmers across the country. These policies protect farmers against severe crop losses due to flood, drought, pests, disease, severe storms and other factors that could greatly damage a farmer's crop production.

In this Basic Training scenario, we introduce the concepts of crop insurance, subsidies, and the mathematical concepts connecting statistics and probability to the real-world risk management needs of the agricultural industry.

Consider the Cornarium Farm, a hypothetical 100-acre corn farm in Kansas that has a typical yield of 150 bushels per acre. We also know that a futures contract price of $3.50 per bushel has been provided for the Cornarium (this is the expected value of the sale of their crop for the next year). Using this information and the additional facts found on the following pages, explore the questions below to help understand and manage the potential risks for the Cornarium and plan appropriate insurance premiums for the FCIC crop insurance policies.

In this scenario you are taking the role of a consulting actuary for the FCIC who is brought in to explore updates to their insurance policies for the Cornarium.

This hypothetical example is a stylized depiction of the true method of determining crop insurance premiums. In this example, we start by assuming that yields have only 2 values: 100 bushels per acre or 150 bushels per acre. This assumption was made to simplify calculating the actuarially fair premium and to highlight the connections between expected market value, insured liability, and subsidized premium costs paid by farmers. In reality, yields can take on a wide range of values, and the true method used to determine actuarially fair premiums accounts for the full range of possible yields and losses in the calculations. This is explored in more detail in the later sections of this scenario.

Part 1:
Insurance Basics

Crop insurance policies typically include some percentage of coverage less than 100%. Meaning that the insurance will not pay out for a complete loss, but only for some percent of loss on a particular field or farm. The FCIC has provided farms similar to the Cornarium insurance policies with 75% coverage, meaning that the policy guarantees the farmer will be paid for any loss where their field yields less than 75% of its typical yield. The FCIC will pay for any yield less than 75% of their typical yield.

1. What is the expected total crop output & market value for the Cornarium's field?

   100 acres * 150 Bushels per acre = 15,000 bushels. At $3.50 per bushel = $52,500 market value.

2. What is the insured yield for the Cornarium field if the FCIC provided a policy similar to other farms in their region?

   0.75 * 150 bushels/acre = 112.5 bushels per acre, or total bushels = 0.75 * 15,000 = 11,250 bushels.

3. What is the total insured liability to the FCIC for the Cornarium field?

   112.5 bushels/acre × 100 acres × $3.50/bushel = $39,375.

Similar farms to the Cornarium in Kansas had an 8-percent chance of being affected by a pest each year that typically produced a loss of a third of their crop.

4. What is the total value of the loss the Cornarium might see if a similar pest infected their field?

   They would lose 50 bushels/acre = 50 * 100 * $3.50 = $17,500.

5. Considering only these two possible outcomes: (1) business as usual without a loss, and (2) an 8% chance of having a pest infestation, what is the "Expected Value" of the Cornarium's corn field?

   0.92 * $52,500 + 0.08 * (100 bushels/acre) * (100 acres) * ($3.50/bushel) = $48,300 + $2,800 = $51,100

6. What is the expected value of the Cornarium's total potential loss?

   0.08 * $17,500 = $1400.

7. What is the total payout the FCIC would pay to Cornarium Farm if they were hit with this pest infestation?

   Insurance covers a yield of 75% of normal, or 112.5 bushels/acre. The pest infestation would create a yield of just 100 bushels/acre, so the insurance policy will pay the difference. (112.5 – 100 bushels/acre) * 100 acres * $3.5/bushel = **$4,375**

8. What is the expected value for the loss payout FCIC would make to the Cornarium Farm in a year?

   0.08 * $4,375 = $350.

Part 2: Subsidies

For some farm insurance policies, the government will provide subsidies to help the farmers ensure their crops. Subsidies can be tied to specific qualities or actions of the farms. For example, a subsidy might be tied to the farmer using a particular pesticide to help control a potentially damaging pest infestation. Consider, PestX – a new pesticide that claims to reduce the likelihood of a pest infestation from 8% to 5%.

9. What is the value of using this pesticide to Cornarium Farms?

   The pesticide reduces the likelihood of loss from 0.08 to 0.05, so the value is the difference, or 0.03, which in monetary terms means (0.03) * 50 bushels/acre lost * 100 acres * $3.50/acre = **$525.**

10. What is the value of having a farm use this pesticide to the FCIC?

    Because the value is (0.08 – 0.05) * $4375 = $131.25

Let's assume the government sets an actuarially fair premium for the Cornarium Farm's insurance policy to be equal to the expected value of the loss you calculated in #8 from the previous section. This way the FCIC would be covering its expected loss with the premium it takes in from the farm.

11. If the government wanted to incentivize Cornarium Farms to use the new PestX pesticide, what new premium could the FCIC offer if Cornarium agreed to use the pesticide?

    The FCIC could offer $350 (the expected loss) - $131.25 (the value of the pesticide) = $218.75.

Part 3:
Probability Charts

Now, let's assume we get some more information about the actual probabilities of the Cornarium Farm's potential yield. Your team has done some additional analysis of other similar farms and has provided you with the following table of yields and their likelihood based on the likelihood of several factors such as pests, floods, droughts, and severe storms happening.

Yield (Bushels/acre)	Probability
150	0.40
140	0.20
130	0.16
120	0.10
110	0.05
100	0.04
90	0.03
80	0.02

12. With this new information what is the expected yield of the Cornarium Farm's corn field?

    Sum the expect probabilities : (0.4 * 150) + (0.2 * 140) + (0.16 * 130) + (0.10 * 120) + (0.05 * 110) + (0.04 * 100) + (0.03 * 90) + (0.02 * 80) = **134.6 bushels / acre**

13. What is the expected market value of the Cornarium Farm based on these updated probabilities?

    134.6 bushels / acre * 100 acres * $3.50/bushel = **$47,110**

14. What is the expected value of the loss the FCIC would pay out to Cornarium assuming the same insurance policy is provided as before (75% coverage from their full 150 bushels)?

    (112.5-110) * 0.05 + (112.5 – 100) * 0.04 + (112.5 – 90) * 0.03 + (112.5 – 80) * 0.02 = 1.95 bushels/acre * 100acres = 195 bushels * $3.50 /bushel = **$682.5**

15. What is the maximum value the FCIC would potentially pay out to the Cornarium under these expected yield probabilities and insurance policy?

    (112.5 – 80) * 100 * $3.5 **= $11,375**

Part 4:
Risks & Recommendations

Let's now assume that the only way farms similar to the Cornarium have seen less the 120 bushels per acre yield is if they were hit with the pest infestation that the insecticide PestX was design to control. Use the probability chart on the previous section to answer these questions about whether the Cornarium should invest in PestX treatments for their farm.

16. If PestX is 100% effective, and assuming that the variability between 150 and 120 bushels per acre is due to other factors not associated with PestX, so that the probabilities for each outcome will increase proportionally with PestX, create a new probability chart for the distribution of potential yields if the Cornarium applies PestX.

Yield (Bushels/acre)	Old Probability	PestX Probability
150	0.40	0.465
140	0.20	0.233
130	0.16	0.186
120	0.10	0.116
110	0.05	0
100	0.04	0
90	0.03	0
80	0.02	0

New probabilities = Old Prob + (Old Prob)/(Old Prob total) * PestX prob

New Probabilities = Old Prob + Old Prob / .86 * .14

17. If PestX cost $25 per acre to apply, is PestX a good idea for the Cornarium to purchase for their farm?

    No, it is too expensive for the Cornarium to invest alone in adding PestX to its farm. The farm's expected value without PestX is $47,110. The farm's expected value with PestX is $49,164.50. However, the cost of applying PestX to all 100 acres is $25 * 100 = $2500. So the expected value minus the cost = $46,664.50, less than their original expected value without PestX.

18. Should the FCIC incentivize farmers to apply PestX? Explain why mathematically.

    Yes, without PestX the FCIC would expect to pay insurance claims worth $682.50 on average. With PestX they are expected to pay no insurance payouts on these policies because the farms would have 0% chance of yielding less than the 112.5 bushels guaranteed by the policy.

19. How much of the $25/acre fee would the FCIC need to pay to make it valuable for the Cornarium to purchase PestX? Would this be a good idea for the FCIC? Explain why mathematically.

    $49,164.5 - $47,110 = $2,054.50 which is the difference in value for the farm. So the cost of purchasing PestX has to be less than this for it to be economically beneficial to the farmer. So $2,500 - $2,054.50 = **$445.50.** Meaning that FCIC must subsidize, or incentivize at least $445.50 of the PestX cost for it to be valuable for the farmer.

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