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Technical Note:	200-ECN-7	**Date:**	10/30/2023
Subject:	ECN Technical Note 7, Economics, "Crop Damages from Flooding		

Purpose: This technical note provides instruction on how to quickly estimate crop losses from flooding and waterlogging conditions.

Expiration Date: Effective upon receipt.

Explanation: Crop damages caused by flooding or waterlogging are not consistent across time, crops, or different amounts of water. While minor, short term soil saturation may leave little to no damage if temperatures are relatively cool, persistent saturation may cause extensive damage if temperatures have been high. Waterlogging alone can decrease crop yields by 33 percent. Additionally, flowing water can scour the soil or deposit excessive sediment, resulting in significant damage to the land. Estimating crop losses under these conditions quickly and consistently is important for emergency watershed activities.

Distribution: This technical note will be distributed through the eDirectives system.

Contact: Contact Bryon Kirwan, Central National Economist, or Adam Reed, Central National Agronomist, with questions regarding this directive.

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ECONOMICS TECHNICAL NOTE

Crop Damages from Flooding
Estimating Losses

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Purpose

This technical note provides instruction on how to quickly estimate crop losses from flooding and waterlogging conditions. For our work as conservationists and planners, making these determinations quickly and consistently is important to emergency watershed activities, in helping producers and owners estimate damages from severe weather events and in explaining how the damage figures were calculated.

These instructions can be used for individual fields or, if damage is widespread, across large landscapes. Please note that these are **estimates.** The expected damage can be affected by a wide range of variables; it is impossible to isolate every potential variable and make an exact assessment.

Introduction

Water is necessary for life on earth. It is critical for humans as well as plants. Water in excess, however, can cause great damage. We have seen pictures of devastation from flooding due to extreme weather events and shifts in the climate. This technical note does not address physical infrastructure; however, you may see damage to physical infrastructure while doing crop evaluations. Do not let the severity or lack of damage to the surrounding environment influence you when evaluating crop damages.

Water is heavy; it weighs 8 pounds per gallon. Flowing water can generate great force that can break plants off or cause them to lodge (i.e., falling over or other displacement), making harvesting difficult. However, the primary danger that water poses to plants is its effect on soil oxygen content. As water accumulates in soil pore space, oxygen is excluded. Plant roots and many beneficial soil microorganisms need oxygen to survive.[1]

[1] *Impacts on Crop Plants from Flooding and Standing Water*. University of Missouri, Integrated Pest Management https://ipm.missouri.edu/cropPest/2021/7/cropFlooding-BW/

Damages

Crop damages caused by flooding or waterlogging are not consistent across time, crops, or different amounts of water. While minor, short term soil saturation may leave little to no damage if temperatures are relatively cool, persistent saturation may cause extensive damage if temperatures have been high. Waterlogging alone can decrease crop yields by 33 percent.[2] Additionally, flowing water can scour the soil or deposit excessive sediment, resulting in significant damage to the land.

The expected effects on different crops will likely be different as well. Evaluating crop and damages is an inexact science, and different individuals may arrive at completely different, but rational and defensible values. The following paragraphs outline some of those range in damage and illustrate both why evaluating crop damage can be difficult and why damages are best expressed in ranges.

Vegetables:

In general, if flooding or waterlogging lasts for less than 48 hours, most vegetable crops can recover. Longer periods will lead to high amounts of root death and lower chances of recovery.[3]

Wheat:

Wheat can probably handle three to four days of flooding and/or waterlogged soils before flooding negatively impacts grain yield as long as some leaves are above water. Higher temperatures will hasten the depletion of oxygen and increase the risk of crop damage.[4]

Cotton:

Waterlogging sensitivity in cotton is strongly associated with growth stage (McLeod 2001) but there is no a priori basis for temporal changes in tolerance. In a series of test-pit experiments, observed 27 to 30 percent yield reduction after 4 to 9 days of waterlogging, respectively, during early reproductive stage in cotton (Wu et al. 2012). A 10-day exposure significantly increased young boll and square abscission in cotton, leading to a 42 percent yield reduction (Jiang et al. 2013). Likewise, reported larger yield losses in cotton waterlogged at early squaring stage (65 DAS) compared with a later growth stage (112 DAS) (Bange et al. 2004).[5]

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[2] How Does the Waterlogging Regime Affect Crop Yield? A Global Meta-analysis. National Institute of Health, National Library of Medicine. PMC (nih.gov)

[3] Flooding, Waterlogged Soils and Effects on Vegetables, With Special Consideration for Plasticulture Vegetables. University of Delaware, Extension Weekly Crop Update (udel.edu)

[4] Wheat Flooding and Waterlogging. University of Minnesota Extension. (umn.edu)

[5] Consequences of Waterlogging in Cotton and Opportunities for Mitigation of Yield Losses. National Institute of Health, National Library of Medicine. PMC (nih.gov)

Rice:
Catling (1992) defined submergence tolerance as "the ability of a rice plant to survive 10-14 days of complete submergence and renew its growth when the water subsides; there is no stem elongation during submergence." Under this definition, submergence tolerance indicates flash-flood tolerance. Generally, the seedlings of many lowland rice cultivars elongate their leaves to get oxygen at the water's surface under submerged conditions. Because this shoot elongation requires large amounts of energy, however, most rice cultivars (i.e., flash-flood intolerant cultivars) have poor ability to recover fully after the water recedes and eventually sustain severe damage or die (Jackson and Ram 2003).[6]

These examples document how the damage might not be consistent. To assist with damage evaluations, it may be helpful to think of the damage as falling within a range rather than as a single point estimate. Following is a listing of some of the major crops and categories you may be asked to address and the associated expected range of damages. To be clear, damages could be worse or less than expected or evaluated. This is to assist in **estimating** damages. There may be a significant error factor. If you are consistent in your evaluation, however, given values will have a defensible methodology in their development.

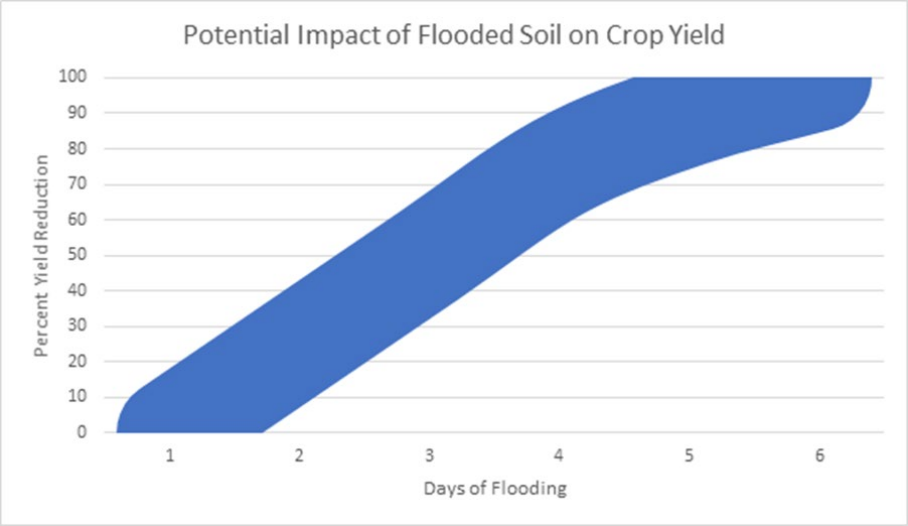
Table 1. Crop Damages Estimates from Flooding and Waterlogged Soils

Crop	**Growth**	**Duration** in Days	**Temperature** Degrees F	**Water Moving**	**Percent Damage** (Percent Yield Reduction)
Corn	<V7	48-96	<70°	No	50%
		48-96	>70°	No	>75%
		>96	>70°	No	>75%
Soybean		48-96	<70°	No	50%
		48-96	>70°	No	>50%
		>144	>70°	No	>75%
Wheat*	Dormant	48-96	<70°	No	unquantified
	Growing	48-96	>70°	No	>75%
Cotton	Growing	>96	>70°	No	30%
Forage	Growing	10 Days	Soil deposition is main concern	Soil deposition is main concern	
Pasture	Growing	10 Days	Soil deposition is main concern	Soil deposition is main concern	
Vegetables	Growing	<48	>70°	No	<30%
	Growing	>48	>70°	No	>75%

[6] Mechanisms for Coping with Submergence and Waterlogging in Rice. Nishiuchi et al. The Rice Journal. Full Text (springeropen.com)

The damages may also be shown graphically, as seen in figure 1. Graphs can be easy to understand and allows a general estimate of damages based on the days of flooding. It may be easier to use a graph rather than a spreadsheet to explain the work you are doing.

Figure 1. The damages may also be expressed graphically as:



Application

To evaluate damage, you must make an inventory of the area, crops, and crop values. These variables would be combined and then evaluated, providing a range of the damage (expressed in dollars).

At the individual farm level, this evaluation is straightforward. For example, an individual has a 160-acre farm. One half of the farm is corn and the other half is soybeans. One quarter of the farm has been waterlogged for 5 days. Both crops are in the reproductive stage of growth. Temperatures have ranged from nighttime lows of 62 degrees Fahrenheit to daytime highs of 87 degrees Fahrenheit.

Out of 80 acres of corn, 20 acres would be expected to have damage in excess of 75 percent. If the production had been expected to yield $800 per acre, the damage would be expected to be $600 per acre, or $12,000 for the corn acres.

Out of 80 acres of soybeans, 20 acres would be expected to have damage in between 50 percent and 75 percent. If the production had been expected to yield $700 per acre, the damage would be expected to be between $350 and $525 per acre, or between $7,000 and $10,500 for the soybean acres.

Added together, the total estimated damage for this farm would be $19,000 to $22,500.

The same process would be used to estimate damages on a widespread basis. The number of acres is only limited by the area of damage. it would simply be a matter of determining the crops, acreages affected, estimated damage, and expected revenue. When damage is over a wide area and several different crops are affected, expect a wide range of estimated damages. Do not let the range in values deter your work.

A large scale example: 1 million acres in the damage area, with the following crops (200,000 acres each): corn, soybean, wheat, cotton, and pasture. 50 percent of the area has been waterlogged for 5 days. Corn is expected to yield $800 per acre, soybeans $700 per acre, wheat $600 per acre, cotton $1,200 per acre, and pasture $300 per acre. Temperatures have ranged between 70 degrees Fahrenheit and 90 degrees Fahrenheit. We would estimate the damage ranges as:

Corn: 100,000 x $800 X 0.75 (damage estimate) = $60,000,000
Or at the 0.50 damage estimate it would be $30,000,000
Soybeans: 100 x $700 x 0.50 = $35,000,000
Wheat: 100,000 x $600 x 0.75 = $45,000,000
Cotton: 100,000 x $1,200 x 0.30 = $36,000,000
Pasture: 100,000 x $300 x ? = ?

We would estimate damage to be from $146 million to $176 million dollars based on the information given. This does not address areas that may have been flooded or waterlogged for only a day or two and any potential damage that may be present. A $30 million range in the estimated damage may sound large, but it may actually be larger.

It is okay to say, “We don’t know,” when there is no information to guide us. In this example, while we may expect some damage to the pasture, we are unable to estimate that damage with the information we have.

Conclusion

Estimating crop losses from flooding and waterlogging is a difficult task. It has a number of complex interacting variables and can have a wide range of outcomes. This technical note provides some background on potential losses based on selections from the agronomic literature.

Taking the agronomic estimated loss factors and adding the economic values of each crop to the equation is how the estimated losses are calculated. The examples provided can serve as a framework for any future estimation you may need to conduct. Additionally, you should also consult with local experts, such as your Land Grant University.

Using the methodology spelled out in this technical note will allow you to estimate damages for a single farm or for widespread damage with the available information. It is important to emphasize that the value you provide is an estimate and not an absolute measurement of loss.

Additional details about estimated crop losses and crop management following floods and waterlogging can be found in the references and citations.

References

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