Economics of Lime

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Yield Impacts from Lime Application

- There have been several studies looking at the yield impacts on various crops associated with both one time and multiple lime applications.
- The economic implications are generally expressed based on yield improvements over time, and usually not in terms of impacts on overall land values or rental rates.
- However, anything that improves productivity should also impact the value of the asset base.

Impact of Soil Acidity

- Plant species and cultivars vary in sensitivity or tolerance to acidic soil. Legumes/vegetables are more sensitive than grasses/cereals. Seedling stage is most susceptible but can be seen at later growth stages, typically in “islands”.

Valuing Productivity

There are two ways to determine value of liming – the short run and the long run.

- **In the short run, any immediate or near immediate response anticipated should result in:**
  - 1) increased rental rate if the landlord incurs entire cost
  - 2) Internalizing benefits to the renter if they incur the entire costs
- **In reality, a cost share arrangement is optimal based on the rental horizon**
- Longer term benefits accrue to the land owner, and should be viewed as investments in capitol improvement.
- Benefits could include both higher long term rental rates for new renters, and increased land values

Land Valuation Model

$$V = \frac{R}{d}$$

Where:

V is the value of land

R is the return

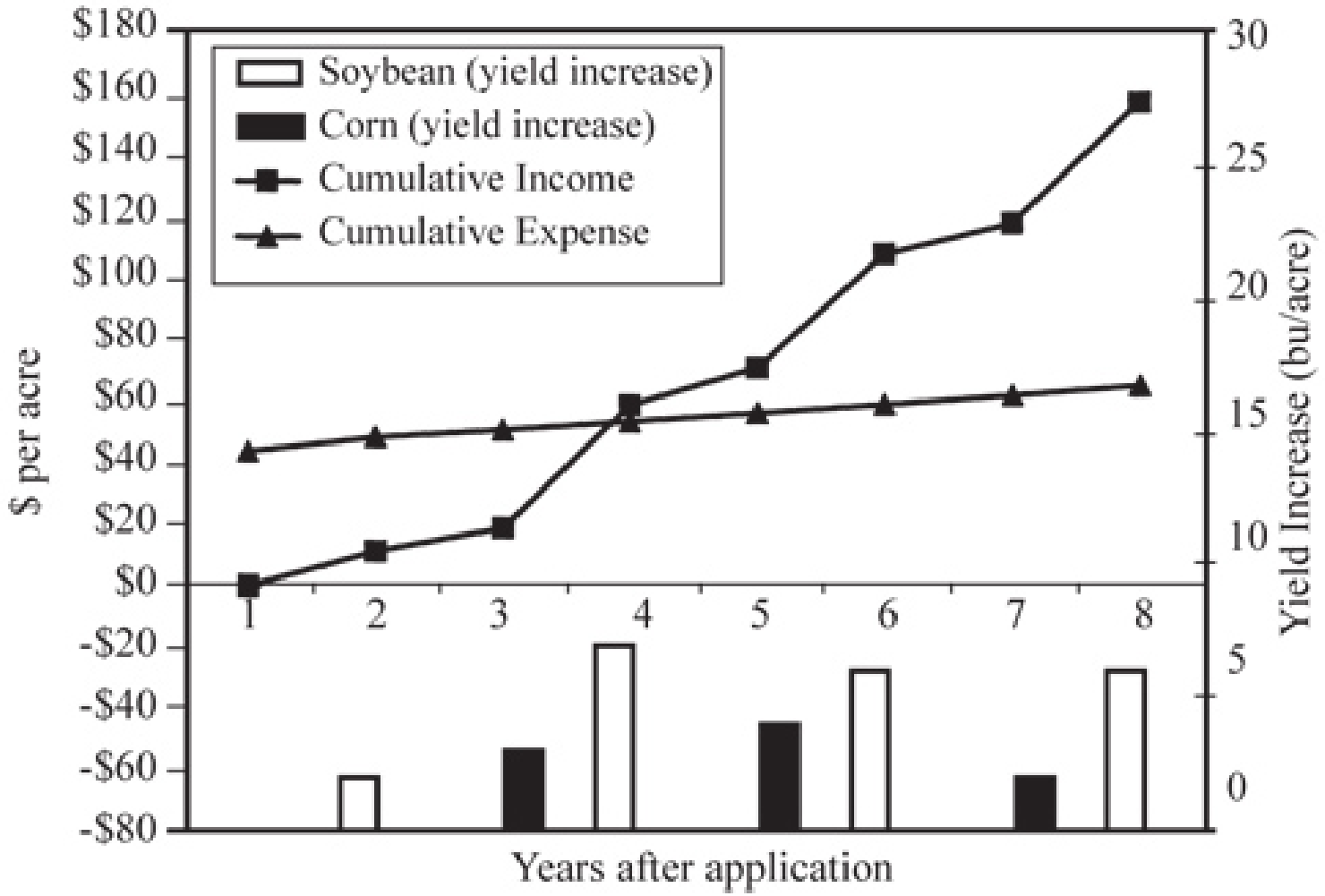
d is the opportunity cost of capital

Land prices increase when:

Returns to land increase (positive relationship)
Opportunity cost of capital decreases (negative relationship)

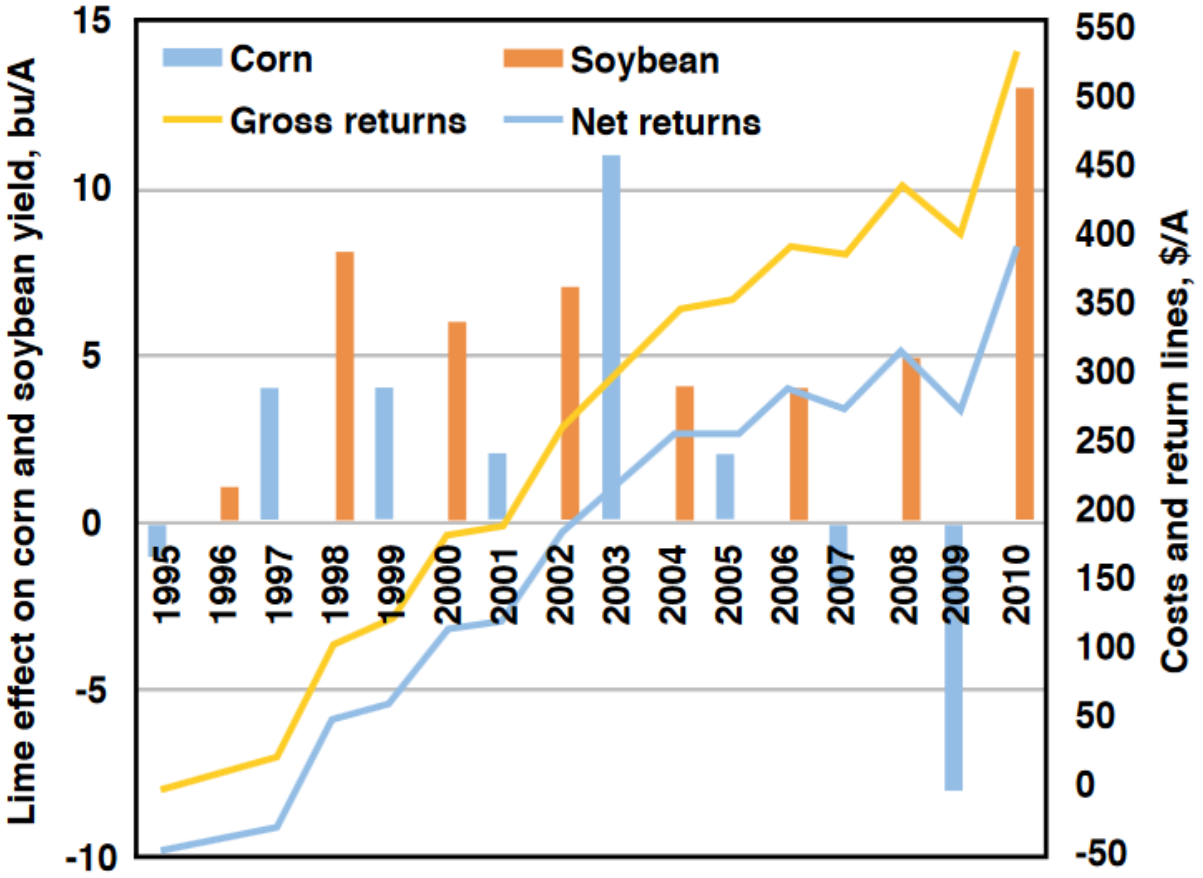
Previous Research

- Much of the work on the economics of liming has been conducted in the Midwest and Great Plains.
- Results vary based on location, initial PH, and cropping systems.
- In general, the cost of liming should be considered an investment over a 5 – 10 year period.
- The returns to that investment are not the same each year, and this is why different lease terms may result in different cost shares between landlords and renters.



Cumulative lime effect with tillage (initial pH of 5.5; liming cost of $44/A). (From J. Peterson and R. Hilgenkamp, Nebraska Soybean and Feed Grains Profitability Project),

Lime is a long term investment



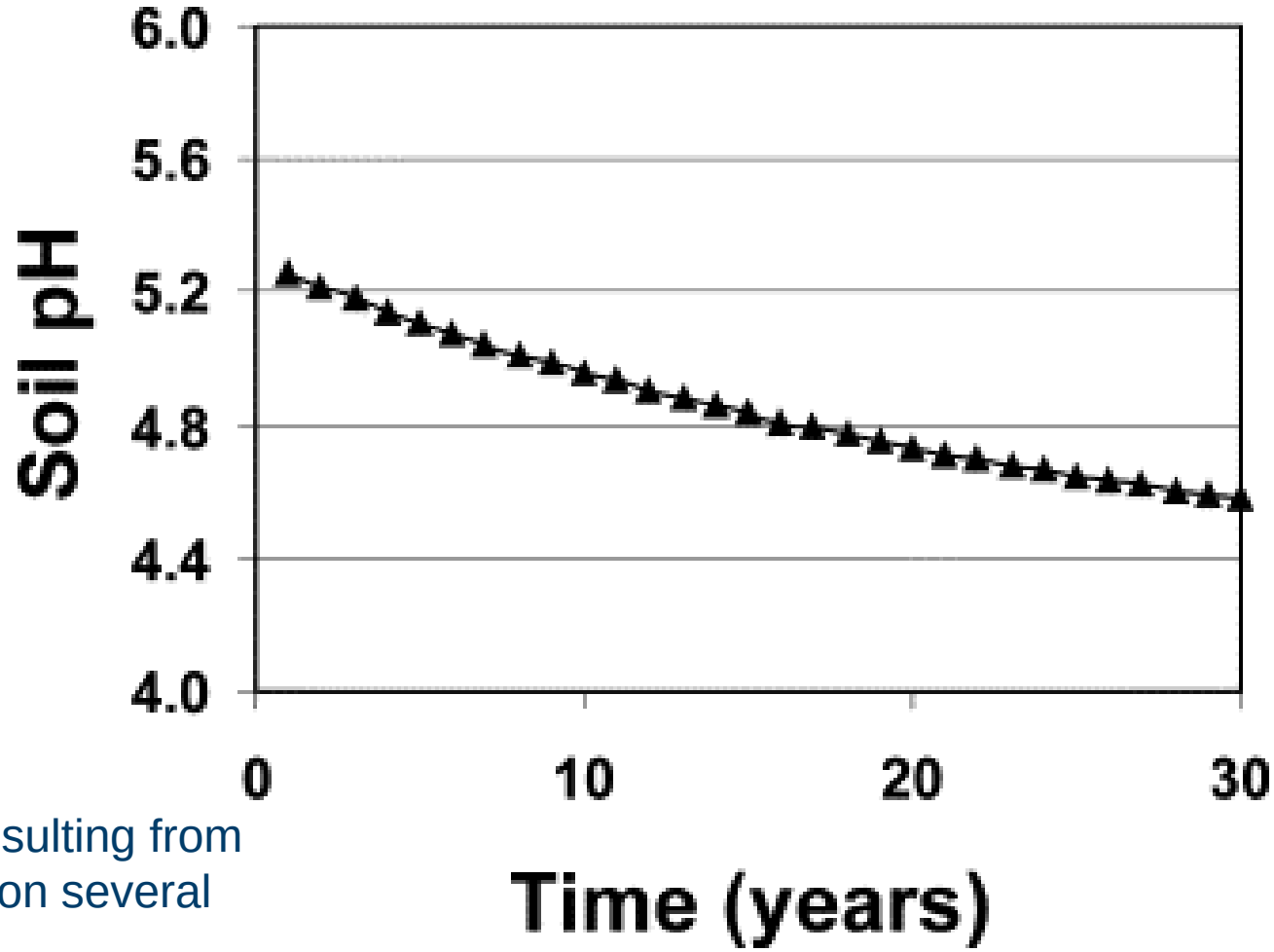
- Starting pH – 5.5
- Ag lime cost - $44/acre
- Price of soybeans ($10/bu) and corn ($4/bu)
- Yield change over 16 yrs
  - + 35 bu/acre – soybeans
  - + 12 bu/acre – corn
- Avg. annual income was greater than expense by year 4
  - 88% of profit came from soybeans

Source: University of Nebraska Publication G1504

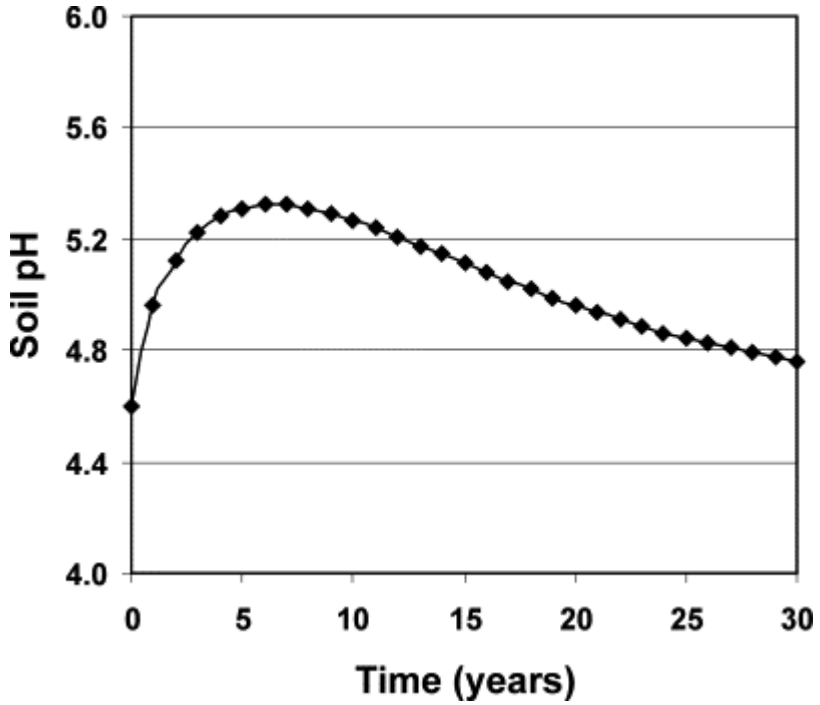
Other Considerations

- Site Specific Applications:
  - PH levels can vary significantly across a field, especially where there are changes in topography, waterways, or differences in historical cropping.
  - The Nebraska study found that in the Southeast part of the state, for example, lime needs on hilltops exceeded needs on slopes by about 21 percent, and slope needs exceeded needs on bottoms by about 16 percent.
  - Soil type, and variation across a field, can also affect lime needs.
- On large tracts variable application rates based on differences across fields may be more economic than a single application rate.

Optimal frequency and quantity of agricultural lime applications (Agricultural Systems, June 2003)



Hypothetical change in pH over time resulting from continuous cropping to wheat – based on several simulation models



Hypothetical change in pH over time after lime application

Wheat Yield Response
Continuous Wheat

- Based on simulations using production data from earlier research, maximum wheat yields were produced when PH was between 5.26 and 6 (this was the minimum PH necessary to achieve maximum yields).
- The differences were based on the type model used to simulate production response.

Land Value Implications
25 Year Planning Horizon
(remember this is from 2002)

Strategy	Initial PH		
	4.1	4.4	4.8
No lime applied (NPV/acre)	$1,155	$1,230	$1,330
Multiple applications (NPV/acre)	$1,430	$1,465	$1,502
First application (tons/acre)	2.85	2.25	1.30
Subsequent applications (tons/acre)	0.30	0.48	0.60
Years applied	1, 10, 13, 16, 19, 22, 25	1,11,16,21	1,10,17

Liming Rented Land
Share Lease

Table 1. Partial Budget Worksheet		
Alternative under consideration:	Liming Acid Soils for Wheat Production	
Added Returns:	Break-even Added returns from 1.28 bushels of wheat	$4.15
Reduced Costs:	Reduction in Phosphate (P_2O_5) expense per acre per year	3.00
(1) Total added Returns and Reduced Costs:		$7.15
Added Costs:	Apply 2 ton lime/acre @ $18/ton, capitalized over 7 years, 9% interest	$7.15
Reduced Returns:	None	—
(2) Total Added Costs and Reduced Returns:		$7.15
Net Income Change (1) – (2)		**0**
Notes: Break-even yield increase to offset $4.15 in added expense from liming: $4.15/$3.25 per bushel = 1.28 bushels per acre.		

Economics of Liming Kansas Cropland
Owner-Operator and Landlord-Tenant Consideration
MF2137 (1995)

Cost Share

Table 3. Production Costs, Landlord Shares and Break-even Yields for Liming Acid Soils in Kansas

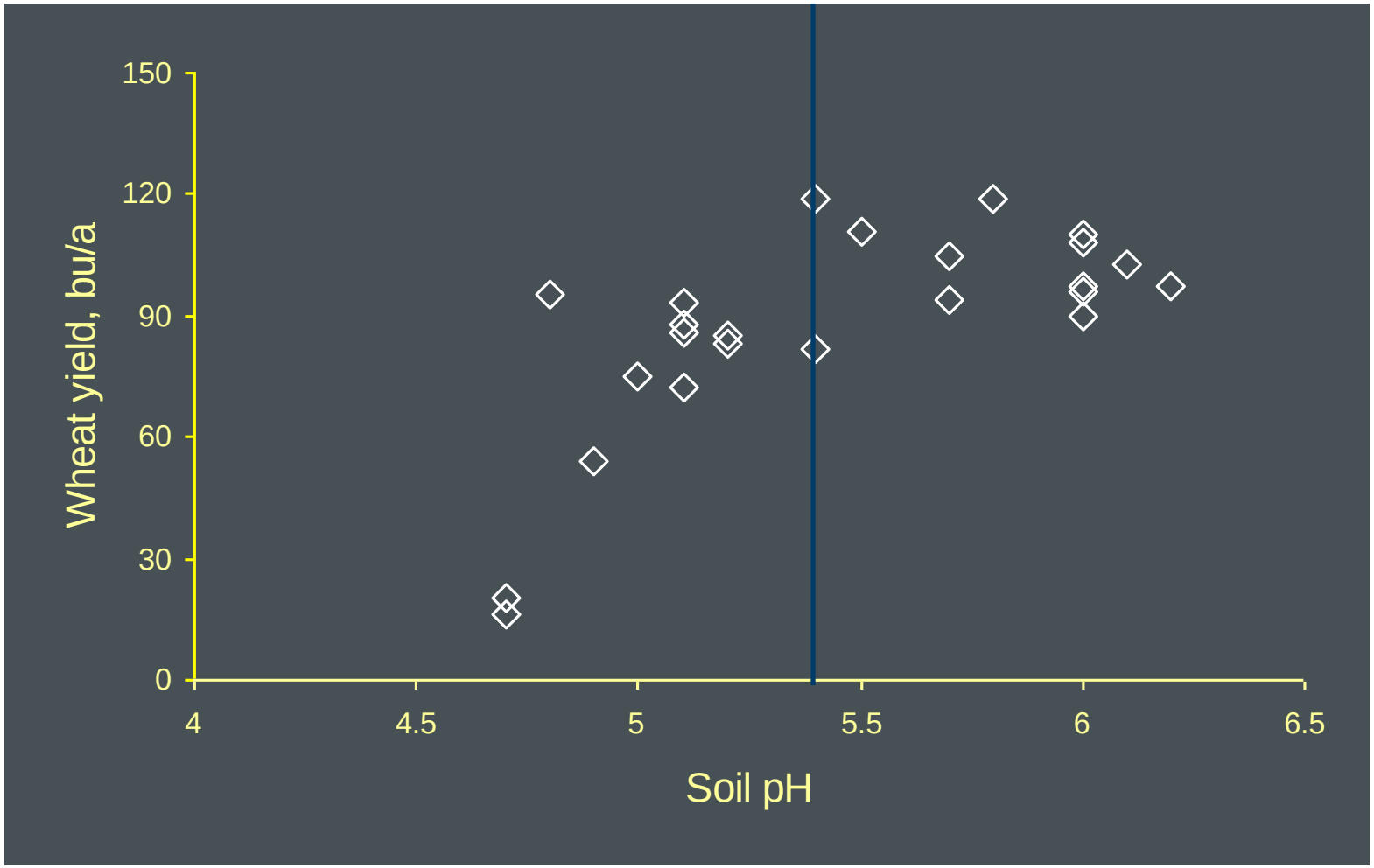
	Crop			
	Wheat		Grain Sorghum	
	No Lime	Lime	No Lime	Lime
Total Economic Cost of Production per Acre	$160.43	$164.58	$183.87	$188.02
Landlord Cost per Acre Includes: Land cost, taxes, lime expense and share of fertilizer	45.85	52	51.78	57.93
Landlord Share as a Percent of Total Cost	28.6%	32%	28.2%	30.8%
Break-even Wheat Yield (bu/a) at $3.25/bushel and $22.75/acre Deficiency Payment	42.36	43.64	—	—
Break-even Grain Sorghum Yield (bu/a) at $2.20/bushel and $18.70/acre Deficiency Payment	—	—	75.08	76.96
Break-even Yield/a Increase Needed to Cover Added Total Costs Due to Liming	—	1.28	—	1.89
Break-even Yield/a Increase Needed to Cover Added Landlord Costs Due to Liming	—	1.89	—	2.8

Two tons of lime per acre are applied. Lime costs of $7.15 per acre per year are derived from a lime cost of $18 per ton, capitalized over 7 years at 9 percent interest. Fertilizer cost per acre per year are reduced by $3.00, which reduces the landlord share of fertilizer expense by $1.00

pH Threshold and Wheat Yield Loss

- Wheat yield decreases when soil pH is below?
  - **5.4**
- How much yield will you lose at pH 5.2?
  - **15%**
- How much yield will you lose at 4.7?
  - **80%**

Soil pH “Waterfall” Effect



Cash Lease Arrangements

- Cost share should be a function of the lease length.
- The lease should also explicitly state lime costs to be returned to the renter if the lease is terminated early.
- The frequency of re-liming is also an important consideration.
- It is in the landlords best interest to maintain PH at the level necessary to insure that it is not a limiting factor in production for as long as the land asses is owned.
- It is in the renters best interest to insure that PH is not a limiting factor over the life of the lease.
- Once PH is stabilized at an appropriate level, then future leases could incorporate an annual charge for the longer-term costs, and these can be borne by the landlord.

General Observations

- Tenants cannot offered to pay for lime if a lease is not at least of a 5 year duration.
- Based on the Nebraska research for corn and soybeans, the cumulative return to the initial application was 10 percent in year 1, 17 in year 2, 55 in year 3, 65 in year 4, and near 100 percent in year 5. Thus, an equitable 3 year lease might include an initial application cost to the tenant equal to 55 percent of total costs, with 45 percent being paid by the landlord.
- If there is an initial 5 year lease, with the tenant paying all liming costs, that is terminated in year 4 than the tenant would want to be reimbursed for 35 percent of the liming costs (these are the benefits accruing in year 5 that the tenant would not receive).

Challenges

- Absentee landlords that do not want to make capitol investments.
- Tenants that are not focused on longer-term productivity.
- Extrapolating from old research, research from a different geography, and research focused on a different cropping system.
- A market that does not explicitly account for PH and potential productivity issues related to low productivity.
- Soil maintenance in periods of low prices and narrow or negative margins.
- Knowledge

Summary

- We need to fund agronomic research in the PNW to determine optimal PH levels, and liming intervals, for our various cropping environments.
- More precise cost share arrangements can be designed once we fully appreciate both initial lime needs, update intervals, and crop responses to less acidic soils.
- Both landlords and tenants should monitor PH in existing lease arrangements, and test for PH when entering into a new lease arrangement.
- Lenders and land appraisers need to account for productivity when valuing land, but to do that accurately we need more research on the interaction between PH and current cropping systems.