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Windbreaks: Are They Effective?

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FIELD WINDBREAKS: ARE THEY EFFECTIVE?

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INTRODUCTION

The current status of agriculture in the United States emphasizes the need to develop efficient production systems. For these systems to be successful, they must optimize the balance between inputs and final production. Windbreaks are one effective method for increasing crop production efficiency. More specifically windbreaks provide protection from soil erosion, reduce abrasion by wind-blown soil, and reduce the risks associated with drought. They improve plant water use efficiency, distribution of irrigation water, and overall irrigation efficiency. Windbreaks enhance natural control of insects, provide wildlife habitat, and add permanence and biological diversity resulting in a more ecologically stable environment.

Are windbreaks effective? Yes! The literature overwhelmingly supports a positive yield response in most crops (Kort, 1988). The real question we should be asking is: Do windbreaks make economic sense? Two years ago at the International Symposium on Windbreak Technology, discussion groups indicated again and again the need to develop in-depth economic data on the benefits of windbreak protection.

In 1984, Brandle et al. developed a first generation model for continuous winter wheat production in eastern Nebraska. The objective of this paper is to develop a more general model of field windbreak economics and to test it under varying economic criteria.

ECONOMIC ANALYSIS

Given a significant yield response to windbreak protection, we calculated the economic profitability of windbreak investments based on the costs and benefits over time. Costs and benefits reflected the cost of land area taken out of production, the period for windbreak maturation, and any alterations in the cost of crop production.

We used a capital budgeting approach to determine the additional net revenue generated by a windbreak investment over the windbreak's economic life. More specifically, we used the net present value of income method whereby the value of the investment at some time in the future is expressed in todays dollars (Aplin & Casler, 1973).

BASIC ASSUMPTIONS

Crop

Four basic crops have been included in the model, corn (*Zea mays* L.), winter wheat (*Triticum aestivum* L.), grain sorghum (*Sorghum bicolor* (L.) Moench.) and soybean (*Glycine max* (L.) Merr.).

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Yield

The effects of windbreaks on crop yields have been summarized most recently by Kort (1988) and Baldwin (1988). For this analysis, yield increases were varied from 1 to 25%. Average base yields for eastern Nebraska (Jose et al., 1988) were used in the initial model. The effects of other average base yields were also included.

Grain Price

A 10-year average grain price for Nebraska was used in the basic model (Wellman and Lutgen, 1988). The effect of different grain prices on the model was included in the analysis.

Windbreak Design

It is important that a windbreak be designed for a given location and objective. However, some generalizations are possible and 3 designs of varying degrees of protection were chosen for the analysis. Each system consisted of a single-row perimeter windbreak on the north, south, and west and a varying number of equally spaced single row interior windbreaks. These systems are summarized in Figure 1. Protection is assumed to begin in the sixth year and is phased in over the next 15 years with full protection reached at age 20. Different heights have been used to reflect differences in species, site quality, and climate.

Establishment and Operating Costs

Costs of establishing the windbreaks included tree stock, site preparation, planting, and weed control. Although most establishment costs occur during the first year, tree replacement and weed control are necessary during the second and third years. We assumed a 10% replacement rate in the second year and a 5% replacement rate in the third year. No cost sharing was included in the basic analysis; however, various levels of establishment costs were used to determine the effect of varying costs on the value of the investment.

In a separate analysis the value of participation in the Conservation Reserve Program was included. Various payment levels were assumed and the effect on the windbreak investment determined.

Production costs for the farm operation were 1988 costs for eastern Nebraska (Jose et al., 1988). Overhead costs were taken to be 5% of the total cash costs of the operation. Management costs were based on yield and varied by crop (Jose et al., 1988).

Discount Rate

The economic analysis was carried out at 3 discount rates: 5%, 11% and 17%. The 5% level represents the historical return on an agricultural investment, 11% is the current lending rate and 17% represents a historical high.

RESULTS & DISCUSSION

Yield Increase

The primary effects of a windbreak are reduction in windspeed and the resulting changes in the microclimate in the sheltered zone (Brandle et al., 1988). These microclimate changes are reflected in growth and development of the crop and ultimately in the yield of the crop. Crop yield response is extremely variable, but in general average yield increases of 5-25% are common (Baldwin, 1988; Kort, 1988). The influence of various economic factors have been evaluated over a range of yield increases.

Windbreak Design

The economic influence of the three windbreak systems on the net present value of the 4 cropping situations is shown in Figure 2. Windbreak system #3 (WB-3) is the most extensive system occupying 9.1% of the total land area. It assumes the slowest rate of tree growth (20 feet in 20 years) and the most conservative estimate of the zone of protection (10H). As such it is the most expensive. It is, however, an economical investment yielding a positive net present value at an 11% discount rate and yield increases of approximately 12%. Windbreak systems #1 (WB-1) and #2 (WB-2) are less extensive occupying 4.0% and 5.4% respectively, of the total land area. Both have higher net present values for all crops at an 11% discount rate and yield increases of 6-7%. Windbreak system #1 assumes a more rapid rate of tree growth (30 feet in 20 years) and an optimistic estimate of the zone of protection (20H). It has slightly higher net present values at lower yield increases than WB-2. Windbreak system #2 assumes a moderate rate of tree growth (25 feet in 20 years), a realistic zone of protection (15H), and has been used as the model system for the remaining analyses.

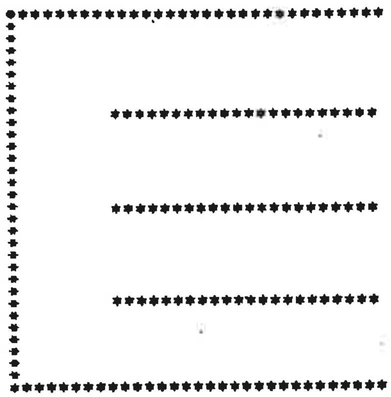
Discount Rate

Figure 3 illustrates the effect of the 3 discount rates on net present value of WB-2 for wheat, corn, grain sorghum and soybeans. In all cases WB-2 is a profitable investment. Even at a 17% discount rate net present value is positive at yield increases of approximately 10%. A comparison of the crops at any given discount rate indicates that the yield increase needed to justify the investment is only slightly dependent on crop but largely dependent on discount rate (Figure 4). Based on these results additional analyses have been done at 11% discount rate and grain sorghum has been eliminated from the analysis.

Average Grain Price

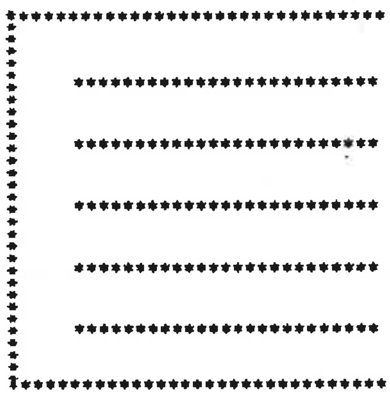
The effect of grain price on net present value is illustrated in Figure 5. Interestingly, the yield increase necessary for a positive net present value appears constant over a range of prices. The magnitude of the net present value, however, is increased significantly with an increase in the cash price.

Windbreak System # 1



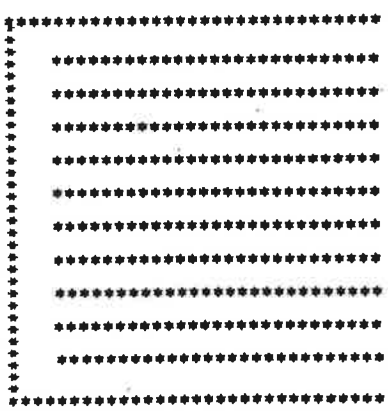
Total acres: 160
Tree acres: 6.4 (4.01%)
Tillable acres: 153.6
Spacing: 21.2 (635 ft)
Effective windbreak ht: 30 ft after 20 yrs
Single row windbreaks
Row width: 20 ft

Windbreak System # 2



Total acres: 160
Tree acres: 8.7 (5.41%)
Tillable acres: 151.3
Spacing: 16.8 (420 ft)
Effective windbreak ht: 25 ft after 20 yrs
Single row windbreaks
Row width: 20 ft

Windbreak System # 3



Total acres: 160
Tree acres: 14.6 (9.15%)
Tillable acres: 145.4
Spacing: 10.9H (218 ft)
Effective windbreak ht: 20 ft after 20 yrs
Single row windbreaks
Row width: 20 ft

Figure 1. Windbreak designs used for net present value analysis.

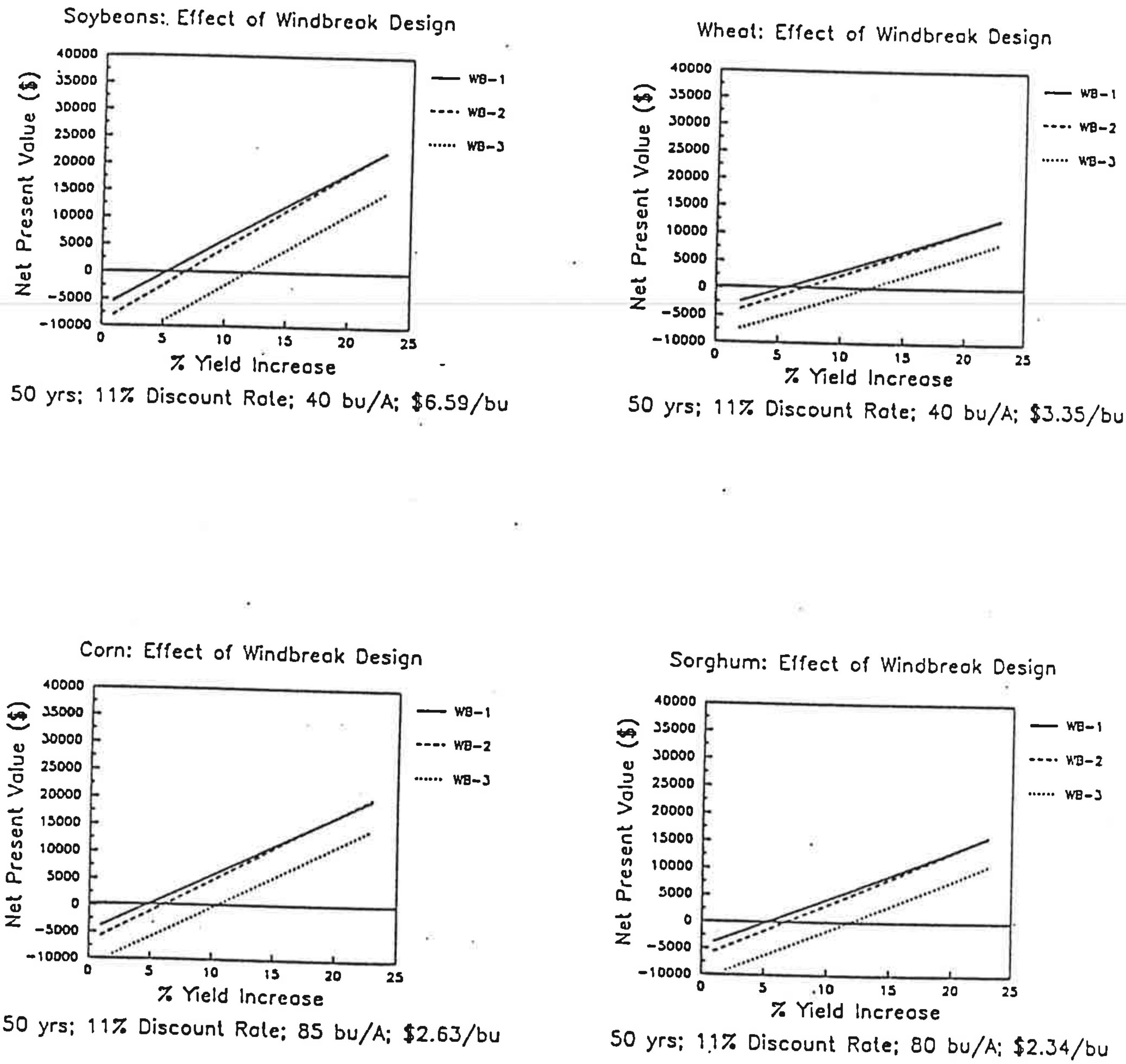


Figure 2. The effect of windbreak design on the net present value of a windbreak investment for 4 grain crops.

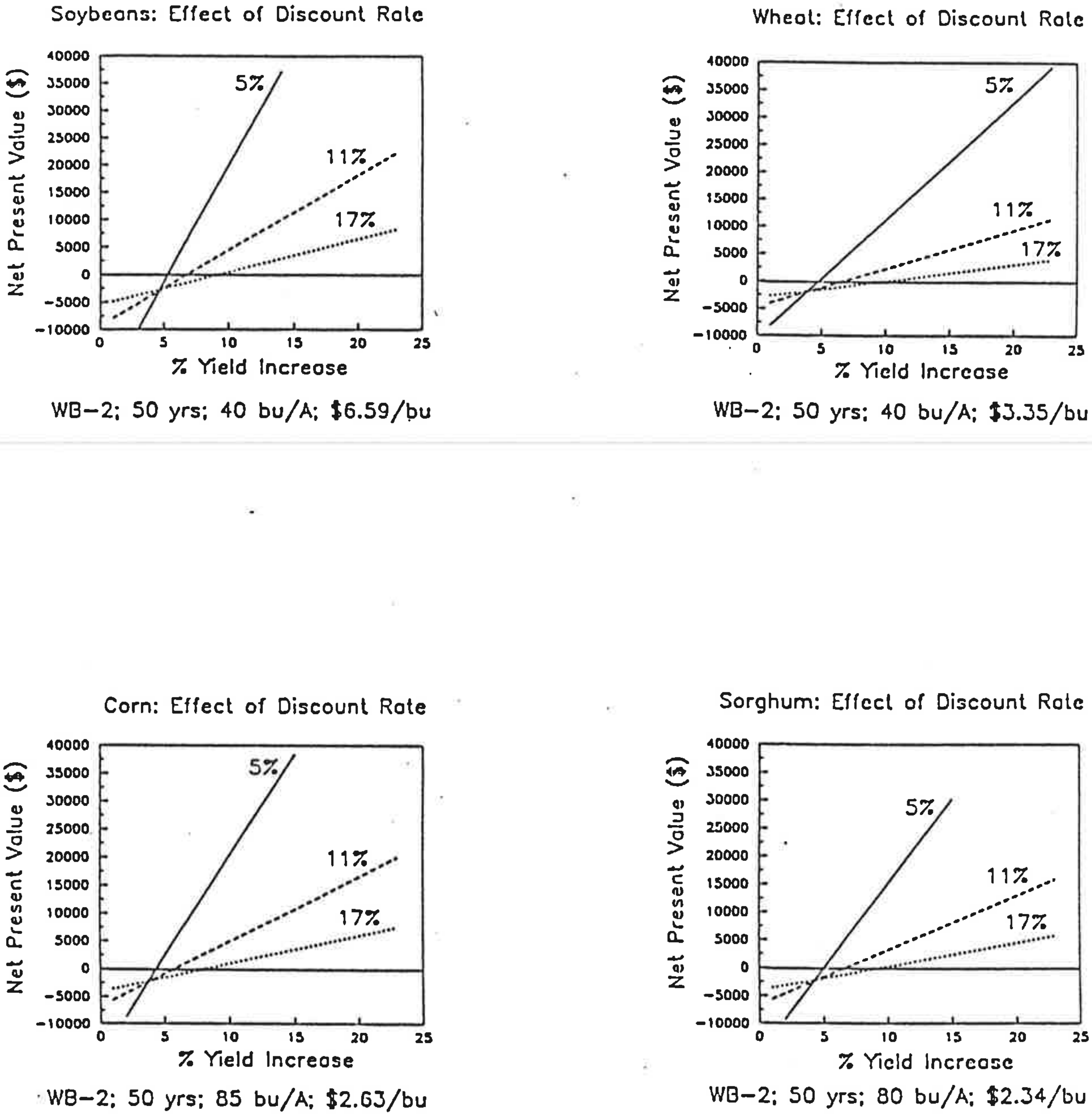


Figure 3. The net present value of a windbreak investment for 4 grain crops at 3 discount rates.

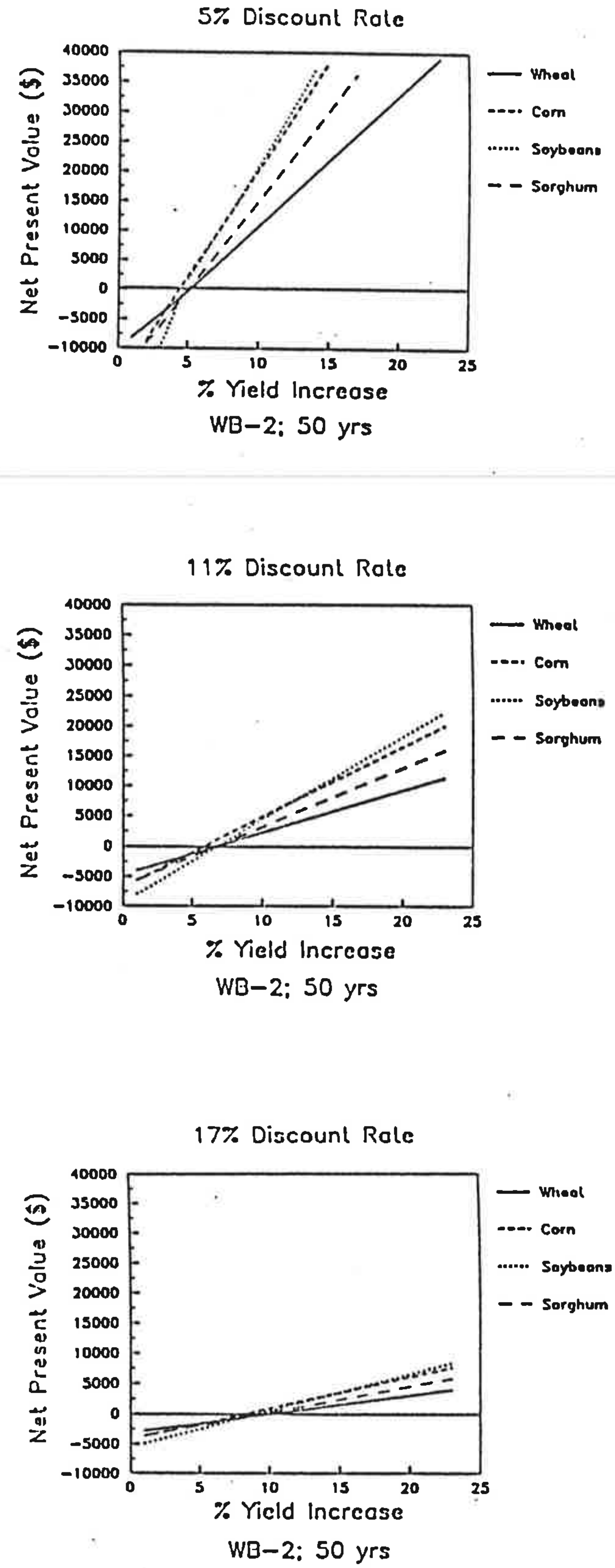


Figure 4. The influence of discount rate on net present value of a windbreak investment.

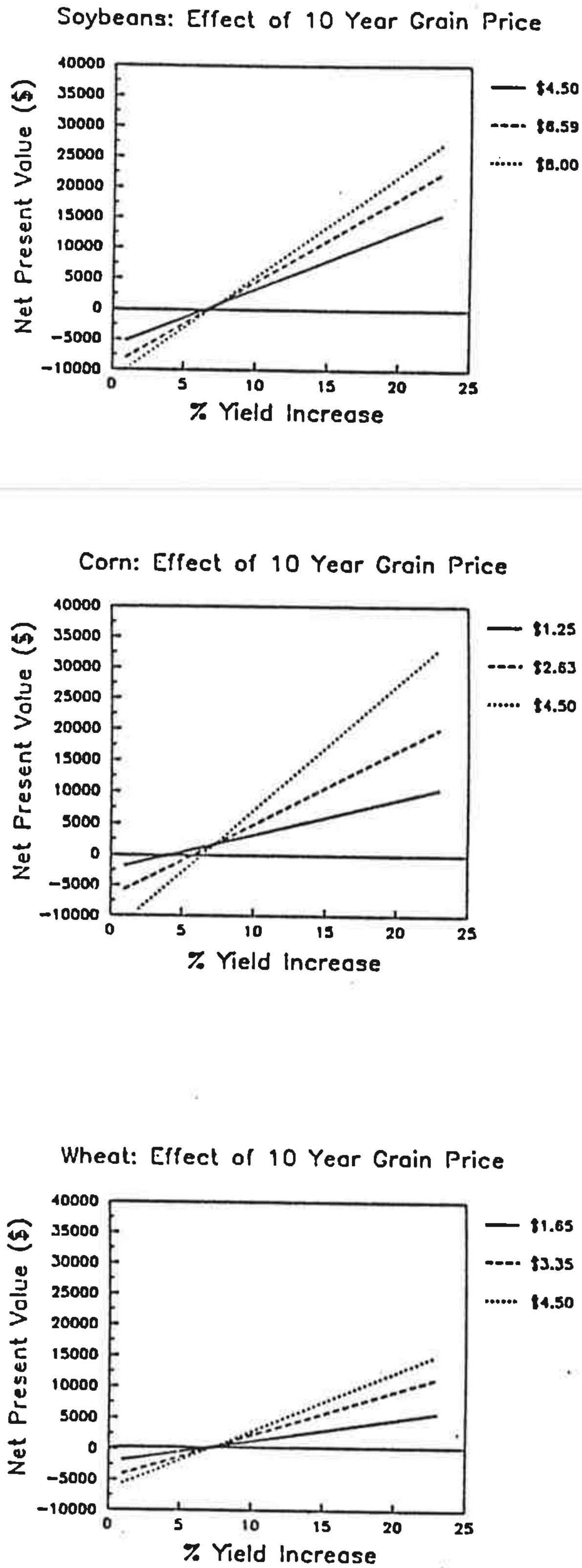


Figure 5. The effect of grain price on the net present value of a windbreak investment.

Average Base Yield

The effect of a change in the average base yield increases the magnitude of the net present value of the windbreak investment (Figure 6). As in the case of grain price the yield increase necessary for a positive net present value appears unchanged. Even at a wheat base yield of only 10 bu/acre the net present value was positive with an increase in yield of 8%.

Establishment Costs

The cost of tree establishing will vary, reflecting local conditions. Typical establishment costs of $0.571/tree for eastern Nebraska were used in developing the basic model. Cost sharing programs also vary and were not included in the basic model, however, these factors should be considered. Figure 7 illustrates 4 levels of establishment costs. A cost of $0.286/tree represents a 50% cost sharing of typical costs for eastern Nebraska. Higher costs of $1.14/tree and $2.28/tree were also included for comparison purposes. Because of the discount rate higher establishment costs had a limited impact on the net present value or on the yield increase required to obtain a positive net present value.

Windbreaks and Conservation

The Food Security Act of 1985 recognizes the need to protect marginal farmlands and has provided the means, via the Conservation Reserve Program (CRP) to return these lands to permanent vegetation. Windbreak plantings are an accepted practice for CRP and, once established, will provide protection to these lands if they are returned to production in the future.

The CRP provides an excellent opportunity for a landowner to install a windbreak system. Cost sharing and CRP payments provide additional income during the establishment period and result in a positive cash flow beginning in year 1 (Figure 8).

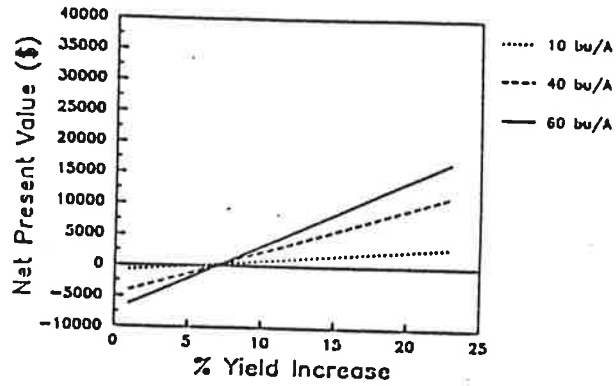
Other Benefits

In addition to crop responses, windbreaks provide other benefits. Foremost among these would be the protection of the soil from wind erosion. There are two types of costs associated with wind erosion. On-site costs include reduced soil productivity and increased operating costs. Off-sight costs which are more difficult to define are also incurred by both the private and government sectors (Huszar and Piper, 1986) and include damage to water storage facilities, irrigation systems, road ditches, and other facilities (Jones and Duey, 1986).

Windbreaks also provide valuable wildlife habitat. In many areas of the Great Plains windbreaks may provide the only significant woody vegetation. Their ecological value in these areas is extremely high.

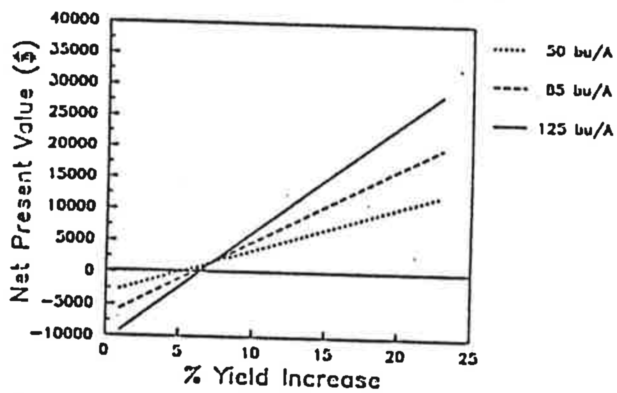
The question of valuation of these types of benefits in the economic analysis of windbreaks is a difficult one. The net present value method discounts the future value of an investment. This implies that the benefits

Wheat: Effect of Average Yield Value



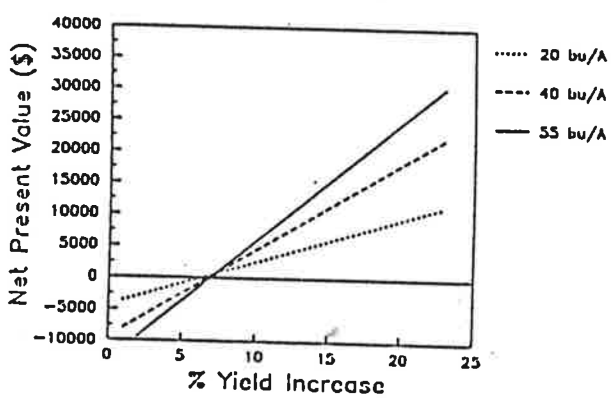
WB-2; 50 yrs; 11% Discount Rate; $3.35/bu

Corn: Effect of Average Yield Value



WB-2; 50 yrs; 11% Discount Rate; $2.63/bu

Soybeans: Effect of Average Yield Value



WB-2; 50 yrs; 11% Discount Rate; $6.59/bu

Figure 6. The effect of a change in the average base yield on the net present value of a windbreak investment.

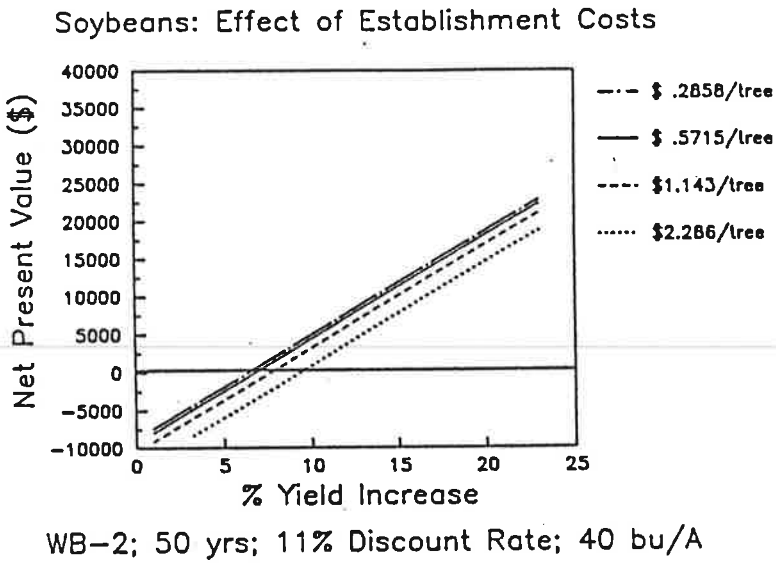


Figure 7. The effect of windbreak establishment cost on the net present value of a windbreak investment.

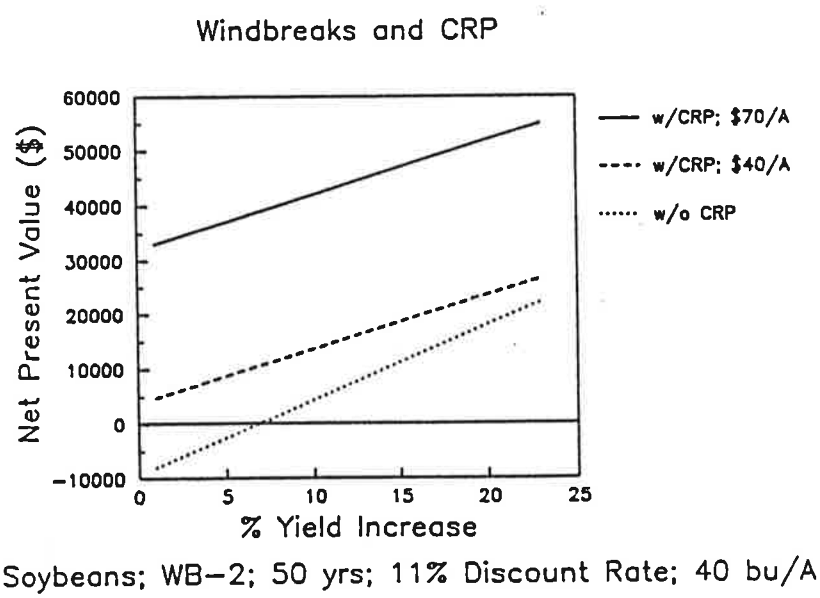


Figure 8. The net present value of a windbreak investment with and without the conservation reserve program (CRP).

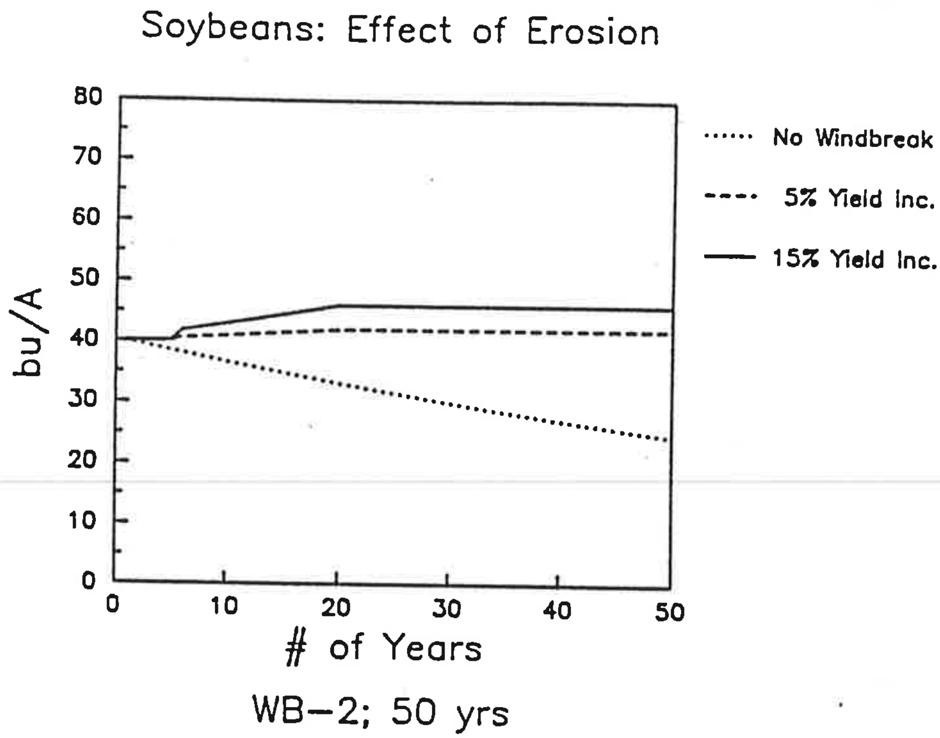


Figure 9. A comparison of Yield benefits of two windbreak situations as compared to yield losses due to wind erosion.

of a resource are worth less the more distant in the future that these benefits will be realized. Obviously from a societal point of view this may not be totally true. Resource preservation for future generations is also an important objective and investments in the conservation of natural resources for future productivity should be encouraged.

Consider the case of soil erosion. If a soil is subject to wind erosion at a rate greater than the tolerance level of that soil then some degree of productivity of that soil is lost. In Nebraska, estimates of lost productive capacity vary from as little as 0.003%/year to as much as 2.35%/year depending on soil type, slope, and exposure (A. Jones, personal communication, 1988). At a loss of 1% of productive capacity per year the unprotected field will yield only 24.7bu/A after 50 years as compared to the protected field with yields of 42bu/A (5% increase) and 46bu/A (15% increase) (Figure 9). This lost production has a net present value of $31,026.21 when discounted over the 50 year period. The net present value of the windbreak investment (WB-2) under a continuous soybean crop with a 15% increase in yield and an 11% discount rate is $42,293.14 ($11,266.93 + $31,026.21).

CONCLUSION

Are windbreaks effective? Yes! Do they make economic sense? Yes!

Using a capital budgeting analysis it is clear that an investment in a field windbreak is economically viable over a wide range of economic and production factors. Longterm yield improvement more than compensated for the cost of establishing the windbreak and for the loss of output from acres taken out of production. The CRP program adds substantially to the economic return of a windbreak investment and a producer should take advantage of the opportunity to enhance future productivity.

The value of wind erosion protection remains and needs further research and analysis. However, the potential costs both on-site and off-site of wind erosion appear to be substantial and may dwarf the value of other factors and benefits in the economic analysis of windbreaks.

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