Estimated Costs of Precision Land Grading With On-Farm Labor

By Michael E. Salassi

Agricultural production in the United States uses vast areas of land. This is one of the primary characteristics that distinguishes agriculture from other industries. In 1999, approximately 330 million acres of land were planted in principal agricultural crops (NASS, 2000). Land is the important basic resource that supports the production of all agricultural commodities, including livestock, which is dependent on land to produce the grain and forage consumed. The total value of farm real estate was estimated to be $745.2 billion in 2000, representing approximately three-fourths of total farm assets (ERS, 1999). Clearly, one of the more important tasks of a farm manager is that of maintaining and improving the productivity of the land resource.

Precision grading of agricultural crop land is an example of a land improvement that can increase the productivity and value of agricultural land. The costs of precision grading represent a long-term investment in the productive capacity and profitability of crop land. The main purpose of precision grading is to level the surface of the field and to grade the field to a specific slope, which will improve drainage of water from the field.

This article presents cost estimates of the precision grading of agricultural fields for the situation in which the producer would purchase the laser leveling and dirt moving equipment and perform the work with on-farm labor. Both variable and fixed costs associated with precision grading are estimated on a per hour of operation basis as well as costs per acre and per cubic yard of soil moved.

Land Grading as a Conservation Practice

Altering the surface of agricultural crop land is a common practice used primarily to improve the drainage of water from a field or to increase the efficiency of surface irrigation. There are several common names for this practice including land smoothing, land leveling, land grading, and land forming. Although each of these practices generally involves altering the land surface, there are distinct differences in the methods used to level the surface of the land (American Society of Agricultural Engineers, ASAE S526.1). Generally, there are two basic types of practices that alter the surface of agricultural land: land smoothing and land grading. Land smoothing involves shaping the land to remove irregular, uneven, mounded, broken, and jagged surfaces without...
using surveying information. This operation would typically be performed by a tractor pulling a land leveler or other type of smoothing implement. Land grading is the operation of shaping the surface of land to predetermined grades so that each row or surface slopes to a drain or is configured for efficient irrigation water application. This operation is typically performed by tractors pulling dirt buckets or scrapers that pick up soil in high points in a field and deposit it in low points in the field. Dirt scraping operations are controlled by laser equipment that enables the slope of a field to be cut to a specific grade. In some cases, the final operations of precision grading would be to use a land leveler to smooth the graded field surface. Land grading is also often referred to as land leveling or land forming.

Several land grading methods are considered to be conservation practices by the Natural Resources Conservation Service of the U.S. Department of Agriculture. Land smoothing (NRCS, code 466) is the practice of removing irregularities on the land surface by use of special equipment. This practice is classified as rough grading and does not require the use of a complete grid survey or other soil engineering data. The purpose of this practice is to improve surface drainage, provide for more effective use of precipitation, obtain more uniform planting depths, provide for more uniform cultivation, improve equipment operation and efficiency, and facilitate contour cultivation. Precision land forming (NRCS, code 462) is the practice of reshaping the surface of land to planned grades. All land-forming operations under this practice are performed on the basis of detailed engineering survey and layout. The purpose of this practice is similar to that of land smoothing, primarily focused on improving surface drainage. Irrigation land leveling (NRCS, code 464) is a conservation practice very similar to precision land forming. The major distinction is that the practice of irrigation land leveling is performed for the primary purpose of increasing surface irrigation efficiency.

Specific soil engineering practices related to the design and construction of surface drainage systems on agricultural lands can be used to improve field drainage (American Society of Agricultural Engineers, ANSI/ASAE EP 302.4). These practices are designed to improve the construction and maintenance of agricultural surface drainage systems, which are adapted to modern farm mechanization. The establishment of a uniform land slope is more important for surface irrigation than for surface drainage (Schwab, et al., 1993; Troeh, et al., 1991). A graded land surface for drainage has a more variable slope than the uniform grade required for surface irrigation. Having a variable graded land slope does not present a problem for surface drainage as long as the graded surface meets the objectives of surface drainage. The primary objectives of surface drainage are: to prevent water from ponding on land surfaces or in surface drains that are crossed by farm equipment, to remove excess water in time to prevent damage to crops, and to accomplish these objectives without excessive soil erosion.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Number of farms</th>
<th>Irrigated acreage</th>
<th>Crop</th>
<th>Number of farms</th>
<th>Irrigated acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn for grain</td>
<td>9,168</td>
<td>1,729,665</td>
<td>Cotton</td>
<td>4,365</td>
<td>1,836,576</td>
</tr>
<tr>
<td>Corn for silage</td>
<td>5,970</td>
<td>475,091</td>
<td>Sugar beets</td>
<td>1,460</td>
<td>269,037</td>
</tr>
<tr>
<td>Sorghum for grain</td>
<td>2,733</td>
<td>287,110</td>
<td>Tobacco</td>
<td>15</td>
<td>100</td>
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<tr>
<td>Wheat</td>
<td>5,427</td>
<td>941,752</td>
<td>Potatoes</td>
<td>710</td>
<td>73,680</td>
</tr>
<tr>
<td>Barley</td>
<td>3,922</td>
<td>268,128</td>
<td>Vegetables</td>
<td>2,772</td>
<td>584,815</td>
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<tr>
<td>Soybeans</td>
<td>6,868</td>
<td>2,079,628</td>
<td>Sweet corn</td>
<td>776</td>
<td>33,278</td>
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<tr>
<td>Dry beans</td>
<td>2,606</td>
<td>210,189</td>
<td>Tomatoes</td>
<td>815</td>
<td>151,487</td>
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<tr>
<td>Rice</td>
<td>7,838</td>
<td>3,205,148</td>
<td>Lettuce</td>
<td>128</td>
<td>53,171</td>
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<tr>
<td>Other small grains</td>
<td>2,086</td>
<td>94,548</td>
<td>Berries</td>
<td>743</td>
<td>2,866</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>26,065</td>
<td>2,754,926</td>
<td>Orchards</td>
<td>13,464</td>
<td>1,199,811</td>
</tr>
<tr>
<td>Other hay</td>
<td>14,669</td>
<td>2,076,313</td>
<td>Other crops</td>
<td>3,091</td>
<td>445,112</td>
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<td>Peanuts</td>
<td>15</td>
<td>1,682</td>
<td>Pasture</td>
<td>28,079</td>
<td>2,622,191</td>
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</tbody>
</table>

Source: Census of Agriculture.
Applicable to Variety of Crop Production Situations

One of the primary purposes for grading or leveling agricultural fields is to improve the efficiency of surface irrigation. Surface irrigation, or gravity flow, methods range from furrow irrigation, whereby the field is irrigated by allowing irrigation water to move across the field by flowing down the row furrows, to flood irrigation as used in rice production, whereby several inches of irrigation water is maintained on the field throughout the growing season. The efficiency of these irrigation methods can be improved substantially by precision grading. A field leveled to a precise grade will ensure furrow irrigation water will travel the entire length of row and not be blocked or diverted by depressions in the field. For flood irrigation, precision grading can allow for a reduction in the minimum depth of water that must be maintained on the field to cover the entire field. By increasing surface irrigation efficiency, irrigation costs are also reduced.

Precision grading land for the purpose of improving surface irrigation efficiency is applicable to a wide variety of crop production situations. Approximately one half of the total irrigated agricultural acreage in the U.S. is irrigated by surface or gravity flow methods. Agricultural acreage irrigated by gravity flow systems, as well as the number of farms using such systems, are listed in Table 1 for 1998. Major crops utilizing gravity flow irrigation systems include corn, soybeans, rice, hay, cotton and orchards. Gravity flow systems are also used on crops ranging from wheat and barley to tomatoes and berries. A large number of farms also use surface irrigation on pasture acreage. The efficiency of surface irrigation on all of these crops could be improved with precision land grading.

Since precision grading constitutes a long term investment in the land, it will require several years of production to recover the costs invested. Therefore, land chosen for precision grading should be land that has a high probability of remaining in production for several years into the future. Examples would include land that the producer owns, land with favorable rental arrangements, land with good crop production

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**Table 2. Estimated costs of precision grading per hour of operation.**

<table>
<thead>
<tr>
<th></th>
<th>Tractor Large 4wd</th>
<th>Scraper 17 cu. yd.</th>
<th>Laser equipment</th>
<th>Labor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>300 ft. Capa.</strong></td>
<td>115,000</td>
<td>32,000</td>
<td>20,000</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Purchase price ($)</td>
<td>115,000</td>
<td>32,000</td>
<td>20,000</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Expected life (years)</td>
<td>10</td>
<td>15</td>
<td>10</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Salvage value a ($)</td>
<td>11,500</td>
<td>3,200</td>
<td>2,000</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Annual use (hours)</td>
<td>1,000</td>
<td>440</td>
<td>440</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Precision grading use b (hours)</td>
<td>440</td>
<td>440</td>
<td>440</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Repair cost factor c</td>
<td>96%</td>
<td>66%</td>
<td>20%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Operating costs per hour:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel costs d</td>
<td>12.96</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>12.96</td>
</tr>
<tr>
<td>Repair costs e</td>
<td>11.04</td>
<td>3.2</td>
<td>0.91</td>
<td>--</td>
<td>15.15</td>
</tr>
<tr>
<td>Labor costs</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Total operating costs</td>
<td>24</td>
<td>3.2</td>
<td>0.91</td>
<td>10</td>
<td>38.11</td>
</tr>
<tr>
<td>Fixed costs per hour:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>10.35</td>
<td>4.36</td>
<td>4.09</td>
<td>--</td>
<td>18.8</td>
</tr>
<tr>
<td>Interest on investment f</td>
<td>6.33</td>
<td>4</td>
<td>2.5</td>
<td>--</td>
<td>12.83</td>
</tr>
<tr>
<td>Total fixed costs</td>
<td>16.68</td>
<td>8.36</td>
<td>6.59</td>
<td>--</td>
<td>31.63</td>
</tr>
<tr>
<td>Total costs per hour</td>
<td>40.68</td>
<td>11.56</td>
<td>7.5</td>
<td>10</td>
<td>69.74</td>
</tr>
</tbody>
</table>

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a Salvage value equals 10 percent of purchase price.
b Estimated grading hours based on 8 cycles per hour, 17 cubic yards moved per cycle, 300 cubic yards moved per acre, and 200 acres precision graded annually.
c Total repair costs over equipment life as a percentage of purchase price.
d Fuel consumption is 14.4 gallons of diesel per hour with diesel priced at $0.90 per gallon.
e Total estimated repair cost divided by total hours of use over the useful life of the equipment.
f Interest on average investment charged at an annual rate of 10 percent.
potential, and land that is not subject to possible residential development.

Cost Considerations
In deciding whether or not to make the investment in precision grading of agricultural fields on a farm, certain key cost considerations must be addressed. The first consideration involves whether the producer should purchase the laser leveling and dirt moving equipment and do the work himself or whether the work be hired out to someone else on a custom hired basis. The second cost consideration is determining how many years of crop production will be required to recover the investment in precision grading costs.

The total amount of acreage on the farm to be leveled is a critical component in this decision of whether to invest in precision grading equipment. If only a small amount of acreage is planned to be graded, for example 200 acres, the producer may choose to hire out the work rather than purchase the equipment for such a small amount of acreage. However, if a large amount of acreage is to be graded over a multiyear period, for example 1,000 acres graded over a five-year period, it would probably be more economical for the producer to purchase the laser leveling and dirt moving equipment and perform the work himself. The costs for a producer buying the equipment and performing the work himself is estimated to be in the range of 50 to 60 cents per cubic yard moved. Costs of hiring out the work to someone else on a custom hire basis is estimated to range between 80 and 90 cents per cubic yard of soil moved.

The number of years of crop production required to recover investment in precision grading costs can be estimated by comparing the precision grading costs per acre with the increased net returns per acre resulting from increased production or the reduction in cultivation, irrigation, and other production costs resulting from increased field efficiency. An estimate of the number of years required to recover precision grading costs can be determined by dividing the precision grading costs per acre by the increased annual net returns per acre.

Estimated Precision Grading Costs
Estimated costs of precision land grading equipment per hour of operation are presented in Table 2. Required equipment necessary for precision grading land includes a tractor, a dirt bucket or scraper, and laser leveling equipment consisting of a field transmitter with trailer as well as receiver and control boxes which are mounted on the tractor. In the example presented in Table 2, costs are estimated for a 300 horsepower, 4-wheel drive tractor pulling a dirt scraper with a 17 cubic yard capacity.

Operating costs per hour for the tractor were estimated at $24.00 per hour. This cost estimate includes fuel and repair costs. Fuel costs were estimated using a diesel price of 90 cents per gallon. Operating costs for the scraper and laser equipment include only repair costs, estimated at $3.20 and $0.91 per hour, respectively. With an hourly wage rate of $10.00, total operating costs for the entire system were estimated to be $38.11 per hour including labor. Fixed costs per hour were estimated based upon assumed years of expected life of the equipment as well as hours of annual use. In this example, hours of annual leveling use were based upon grading 200 acres of land annually with an average of 300 cubic yards of soil moved per acre. Fixed costs for the entire precision grading system were estimated to be $31.63 per hour of use. Total costs of this land leveling system, including operating

<table>
<thead>
<tr>
<th>Table 3. Estimated costs of precision grading per acre and per cubic yard of soil moved.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Tractor Large 4wd 300 hp</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>Total costs per acre</strong></td>
</tr>
<tr>
<td>Operating costs</td>
</tr>
<tr>
<td>Fixed costs</td>
</tr>
<tr>
<td>Total costs</td>
</tr>
<tr>
<td><strong>Total costs per cubic yard</strong></td>
</tr>
<tr>
<td>Operating costs</td>
</tr>
<tr>
<td>Fixed costs</td>
</tr>
<tr>
<td>Total costs</td>
</tr>
</tbody>
</table>

* Estimated grading hours based on 8 cycles per hour, 17 cubic yards moved per cycle, 300 cubic yards moved per acre, and 200 acres precision graded annually.
and fixed costs, were estimated to be $69.74 per hour of operation. These estimated costs per hour of operation were then used to calculate the costs per acre and costs per cubic yard of soil moved for a specific precision grading example. Results of these calculations are presented below.

In this example, it was assumed that 200 acres of land were being precision graded annually with an average of 300 cubic yards of soil moved per acre. Time requirements per acre were estimated assuming that the grading equipment could make 8 cycles of picking up and moving soil per hour. Using a scraper with a 17 cubic yard capacity, it was estimated that the equipment in this example could move 136 cubic yards of soil per hour. With an average of 300 cubic yards of soil moved per acre, it was estimated that 2.2 hours of operation were required for each acre precision graded. Estimated costs of precision grading on a per acre and per cubic yard basis are presented for this example in Table 3. Operating costs, including fuel, repairs, and labor, were estimated to be $84.84 per acre. Fixed costs were estimated to be $69.59 per acre, resulting in estimated total costs of $153.43 per acre to move 300 cubic yards of soil. On a cost per unit of soil moved basis, this total cost estimate translates to a total cost of $0.51 per cubic yard of soil moved. Operating costs were estimated to be $0.28 per cubic yard and fixed costs were estimated to be $0.23 per cubic yard. The impacts of changes in volume of soil moved per acre on grading costs per acre and per cubic yard are shown in Table 4 for 200, 300, and 400 cubic yards of soil moved per acre. Total grading costs were estimated to be $0.59 per cubic yard for 200 cubic yards of soil moved per acre and were estimated to decrease to $0.47 per cubic yard for 400 cubic yards of soil moved per acre.

Summary
The grading of agricultural land is a typical type of land improvement that can increase the productivity and profitability of crop land. Such operations can range from land smoothing, in which case the surface of the field is smoothed of irregularities without the use of grid survey or engineering data, to land grading, which involves grading the field surface to a specific slope using laser leveling technology. Both of these types of field operations are considered to be conservation practices, the purpose of which are to improve field drainage or to increase surface irrigation efficiency.

In the production of crops irrigated by surface or gravity flow systems, precision grading of fields provides an opportunity to increase irrigation efficiency and thereby reduce irrigation costs. A critical decision for agricultural producers is whether to buy the laser and dirt moving equipment and perform the work or hire it out on a custom basis. Total costs of performing the precision grading operations with on-farm labor are estimated to be in the range of 50 to 60 cents per cubic yard of soil moved compared to costs of 80 to 90 cents per cubic yard for hiring out the work to someone else on a custom hire basis.

References

Table 4. Impact of average volume of soil moved on estimated precision grading costs.

<table>
<thead>
<tr>
<th>Average volume of soil moved per acre</th>
<th>200 cu. Yds.</th>
<th>300 cu. Yds.</th>
<th>400 cu. Yds.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total costs per acre: a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating costs ($)</td>
<td>60.04</td>
<td>83.84</td>
<td>107.64</td>
</tr>
<tr>
<td>Fixed costs ($)</td>
<td>57.91</td>
<td>69.59</td>
<td>81.26</td>
</tr>
<tr>
<td>Total costs ($)</td>
<td>117.95</td>
<td>153.43</td>
<td>188.9</td>
</tr>
</tbody>
</table>

| Total costs per cubic yard: a        |              |              |              |
| Operating costs ($)                  | 0.3          | 0.28         | 0.27         |
| Fixed costs ($)                      | 0.29         | 0.23         | 0.2          |
| Total costs ($)                      | 0.59         | 0.51         | 0.47         |

* Cost estimates based on grading 200 acres of land per year.


