

## Shrub Willow Budget for Biomass Production

Shrub willow (*Salix* spp.) is a fast-growing woody plant with excellent potential as a feedstock for bioenergy production. Moreover, willow can be grown on poorer and wetter soils and provide rural economic development opportunities and environmental benefits.

This fact sheet provides an enterprise budget for growing willow as a dedicated energy crop. The purpose of this fact sheet is to help growers to understand the primary inputs, costs, and potential revenues involved in cultivating willow from planting to harvest. An example budget is described, but because each situation is different and prices can vary, a spreadsheet is available at [extension.psu.edu/natural-resources/energy/field-crops/resources](http://extension.psu.edu/natural-resources/energy/field-crops/resources) for adjusting inputs and prices to individual conditions. The scenario provided in this fact sheet is based on growing the crop primarily in Pennsylvania and/or New York, but it is applicable to surrounding states. All quantities and prices are on a per-acre basis. The costs are based on farm custom rates published by Penn State Extension from USDA-NASS data for 2014. Costs and revenues were kept conservative to not raise expectations. Additional information on cultivating willow and its benefits is available at from the NewBio project website ([www.newbio.psu.edu](http://www.newbio.psu.edu)), Willowpedia ([willow.cals.cornell.edu](http://willow.cals.cornell.edu)), and the State University of New York College of Environmental Science and Forestry (SUNY ESF, [www.esf.edu/willow](http://www.esf.edu/willow)).

This scenario assumes that year 0, or “the present,” is the establishment year and includes site preparation that should be done the fall before planting. The willow is coppiced (“cut to ground”) in the first year after establishment, and harvested every 3 years thereafter. The budget scenario discussed below is based on 7 rotations (or a 22-year timeline), with harvests in years 4, 7, 10, 13, 16, 19, and 22. After 22 years, growers might consider whether replanting with improved cultivars would be more profitable. Other willow harvest rotations are possible, and the spreadsheet online can be used to adapt alternative scenarios. This fact sheet provides only farm-gate prices; it does not discuss transportation costs of harvested willow from the field to storage

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Establishing willow biomass crops by planting one-year-old stems of selected willow cultivars.

or processing facility, which will vary from site to site. For more detailed willow budget scenarios that include many of these additional costs, refer to the “EcoWillow” economic model available at [www.esf.edu/willow](http://www.esf.edu/willow).

### Land Costs and Taxes

Land rental costs and associated annual taxes, such as property taxes, should not be ignored, especially if you are leasing or renting the land. However, many farmers who already have land available would not have to account for land costs in this type of budget as it is a sunk cost and would be the same for whatever land use is applied. Land costs vary from region to region as they are based on soil quality, other site factors, and local tax rates. This budget scenario does not include a land cost per acre, but the online spreadsheet has a section to include it, if needed.

### Soil Test

The first step is to evaluate the land quality for growing willow, which includes a soil test. Willow grows in well-drained to poorly drained soil with a pH of 5.5 to 8.5. A standard soil test is recommended to determine the nutrient availability for willow establishment. The test is generally done based on a grid sampling of 5-acre units prior to planting. Assuming \$15 per soil test, testing will cost \$3 per acre in the establishment year.

## Site Preparation

The amount of work needed to prepare a site varies depending on previous land use. If the growing site is already in annual crop production, less site preparation is required than for unmanaged pasture or brushland. We have budgeted for the land as unmanaged pasture. Clear undesirable brush and weeds with a brush mower, which will cost about \$25 per acre, and then spray it with a broad-spectrum herbicide in the fall. Next, any lime amendments should be made. If erosion is an issue, a cover crop can be established the fall before planting. The land could be zone- or strip-tilled in the spring at a one-time cost of around \$24 per acre. Alternatively, one pass of deep moldboard plowing in the fall and cross-disking in the spring should be done when the field is dry enough at total costs of roughly \$35 and \$38 per acre, respectively. In the scenario provided, we carry out the plowing and disking option.

## Soil Amendments

Willow is adapted to many soil conditions, so it does not usually need high amounts of soil amendments, although best management practices for nutrient amendment are still being developed at Cornell University and the State University of New York College of Environmental Science and Forestry. The online spreadsheet provides ability to include several types of soil amendments as needed. Fertilizer application is charged at an annual cost of \$11 per acre. Manures or other organic amendments can also be used at appropriate substitution rates and methods of application.

- Nitrogen fertilizer is typically applied at about 100 pounds per acre in the first year (after establishment year) and as needed after harvest (every 3 years). Each nitrogen application costs \$56 per acre.
- If soils analysis indicates low phosphorus, monoammonium phosphate (MAP) should also be applied.
- Lime is needed if soil pH is below 5.5.

## Planting

There are numerous cultivars of shrub willow; check with **DoubleAWillow.com** or Willowpedia ([willow.cals.cornell.edu](http://willow.cals.cornell.edu)) for the most appropriate cultivar for biomass production in your area. Willow is grown from one-year-old stem cuttings that are mechanically cut to length (about 6- to 8-inch stem sections) and planted using a specialized willow planter at a rate cost of about \$100 per acre. These willow planters are currently available for rent through the NewBio project. The typical spacing between plants and rows calls for about 6,000 cuttings per acre. The assumed price per cutting is about \$0.09, and the total cost of cuttings is \$540 per acre.

## Weed Control

Weed management during the planting season is crucial for establishment as the crop is sensitive to weed competition. As part of site preparation work, an initial burndown with 32 ounces per acre of glyphosate should be applied in the fall to kill perennial and other problem weeds, costing an estimated \$7 per acre. A preemergence application of SureGuard (6 ounces dry per acre) should be made within 48 hours of planting for weed control. Current prices for SureGuard are about \$154 per pound, so 6 ounces cost about \$58. A



Four-year-old willow biomass crops being harvested.

postemergence herbicide using 8 ounces per acre of Transline to kill broadleaf weeds and Assure II at 10 ounces per acre with surfactant to kill grass weeds is suggested during establishment and the first years. Transline is \$128 per half gallon, so 8 ounces cost \$16 per acre. Assure II is \$90 per gallon, so 10 ounces cost \$7 per acre. The sprayer cost for the three passes discussed above is about \$11.50 per acre per spray, so \$34.50. Contact your county extension office for the latest herbicide recommendations and always follow label recommendations.

## Maintenance Costs

As mentioned above, some fertilizer applications are made after harvest over time as needed. By year 2 (3 years after planting) there should be no need for more herbicide because the willow canopy will shade out the weeds. Occasional and sporadic outbreaks of leaf sawfly, eastern tent caterpillar, or gypsy moth can be very damaging, especially in a young stand, and may need to be controlled with a pesticide such as carbaryl or pyrethrin.

## Harvesting Costs

Willow is coppiced in the first year with no marketable biomass yield. This requires a sickle bar mower or discbine mower, which costs about \$10 per acre. Willow can be harvested in late fall/winter of years 3 or 4 and every 3 years thereafter. This scenario assumes a harvest in year 4 and then 7 rotations for 22 years (in years 4, 7, 10, 13, 16, 19, and 22). Custom harvest machinery is used, such as specialized self-propelled forage harvesters equipped with a cutting head designed to cut woody crops or specially designed forage choppers pulled by tractors. Harvest costs also include chip wagons, trucks, and labor. Such equipment is available for rent through the NewBio Project. Harvest costs vary by type of equipment used, land and operating conditions, and collection efficiencies. An average cost of \$30 per dry ton is estimated using the New Holland forage harvester and specialized header, for a total cost of \$360 per acre (\$30 x 12 tons of material harvested; see next section).

## Yield and Revenues

A conservative yield of 4 dry tons (8 wet tons) per acre per year is expected (12 dry tons every 3 years). Take note that prices may be reported either in wet (fresh) or dry tons. The difference is moisture content. Generally, 50 percent moisture content is assumed in a

	Quantity	Unit	Price/ Unit	Estab- lishment Year (Year 0)	Year 1	Year 4 (First Harvest)	Years 7-22 (per Year) <sup>1</sup>	Total	Present Value <sup>2</sup>
<b>Select Cash Expenses</b>									
<b>Land Costs</b>									
<b>Rental and/or taxes</b>	annual	acre		\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
<b>Plant Material</b>									
<b>Seed</b>	6,000	cuttings/ acre	\$0.09	\$540.00	\$0.00	\$0.00	\$0.00	\$540.00	\$540.00
<b>Soil Fertility<sub>3</sub></b>									
<b>Nitrogen</b>	100	lb/acre	\$0.56	\$0.00	\$56.00	\$0.00	\$0.00	\$56.00	\$54.00
<b>P<sub>2</sub>O<sub>5</sub></b>	0	lb/acre	\$0.63	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
<b>K<sub>2</sub>O</b>	0	lb/acre	\$0.48	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
<b>Fertilizer application</b>	1	acre	\$10.60	\$0.00	\$10.60	\$0.00	\$0.00	\$10.60	\$10.00
<b>Lime<sup>4</sup></b>	0	ton	\$38.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
<b>Soil testing<sup>5</sup></b>		soil test	\$15.00	\$3.00	\$0.00	\$0.00	\$0.00	\$3.00	\$3.00
<b>Weed Control</b>									
<b>Burndown</b>	32 ounces of glyphosate	acre	\$6.50	\$6.50	\$6.50	\$0.00	\$0.00	\$13.00	\$13.00
<b>Preemergence<sup>6</sup></b>	6 ounces	acre	\$9.63	\$57.78	\$0.00	\$0.00	\$0.00	\$57.78	\$58.00
<b>Postemergence<sup>6</sup></b>	8 ounces of Transline + 10 ounces of Assure II	acre	\$23.00	\$23.00	\$23.00	\$0.00	\$0.00	\$46.00	\$45.00
<b>Sprayer (3 sprays)<sup>7</sup></b>	3	acre	\$11.50	\$34.50	\$34.50	\$0.00	\$0.00	\$69.00	\$68.00
<b>Establishment and Maintenance</b>									
<b>Brush mowing<sup>7</sup></b>	1	acre	\$25.00	\$25.00	\$0.00	\$0.00	\$0.00	\$25.00	\$25.00
<b>Zone- or strip-tilling<sup>7</sup></b>	1	acre	\$23.90	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
<b>Disking (2 passes)<sup>7</sup></b>	2	acre	\$17.50	\$35.00	\$0.00	\$0.00	\$0.00	\$35.00	\$35.00
<b>Soil finish (2 passes)<sup>7</sup></b>	2	acre	\$18.90	\$38.00	\$0.00	\$0.00	\$0.00	\$37.80	\$38.00
<b>Willow planter</b>	1	acre	\$100.00	\$100.00	\$0.00	\$0.00	\$0.00	\$100.00	\$100.00
<b>First-year coppice mow- ing (using discbine)</b>	1	acre	\$10.00	\$0.00	\$25.00	\$0.00	\$0.00		\$24.00
<b>Harvesting</b>									
<b>Cutter, chipper, and wagons<sup>8</sup></b>	1	acre	\$360.00	\$0.00	\$0.00	\$360.00	\$360.00	\$2,520.00	\$1,556.00
<b>Total cash expenses</b>				\$863.00	\$156.00	\$360.00	\$360.00	\$3,513.00	\$2,568.00
<b>Revenues</b>									
<b>Biomass</b>									
<b>Mature yield (estimation)</b>	4	dry ton/ acre/year				12	12	84	
<b>Revenue stream</b>			\$45.00	\$0.00	\$0.00	\$540.00	\$540.00	\$3,780.00	\$2,334.00
<b>Revenue above expenses</b>				-\$863.00	-\$156.00	\$180.00	\$180.00	\$267.00	-\$234.00
<b>Equal annual income (annualized over 22 years)</b>									-\$16.00
<b>Breakeven payback period</b>									7
<b>Assumptions: interest rate</b>									4%

wet ton, so mass is double compared to a dry ton. Farm-gate prices for willow chips can vary due to market competition, location, and fuel use. As mentioned above, we are not reporting delivered prices, which include storage and transportation costs to a conversion facility. This scenario uses an assumed farm-gate price of \$45 per dry ton of chipped material. At present, this is a competitive price in northern New York where most of the willow is currently grown. Revenue would be 12 tons x \$45, or \$540 per acre every harvest cycle.

## Net Revenues and Financial Analysis

The last columns of the spreadsheet show the total costs, revenues, and present value of each item. Keeping costs and prices conservative resulted in a scenario for this publication with little if any net returns. The total costs (cash expenses) over 22 years are estimated to be \$3,513 per acre, while total revenues are estimated at \$3,780 per acre. Net income is \$267 per acre for the 22-year budget period. The payback period—which tells investors how long it will take for revenues to cover establishment costs—is 7 years using the financial assumptions in this scenario. In other words, after the second harvest all costs are paid back. One can see from the spreadsheet that harvesting is the major cost of producing willow.

Because this project occurs over a 22-year period you need to account for the time value of money to get an accurate value. Money received in future years is not worth as much as in earlier years. The time value of money is reflected in an interest (discount) rate used by investors. This allows investors to compare alternative projects over the same lifetime, especially since there are other uses for the land (i.e., opportunity costs). To account for future values, revenues and costs not received today are “discounted” to the present, hence net present value (NPV). If the NPV is positive, it implies that investors receive at least their acceptable rate of return (discount rate). The NPV in this scenario, using a 4 percent rate, is -\$234 per acre. This NPV would obviously change if the discount rate, project length, and the costs and revenues were changed. The internal rate of return (IRR, not shown) would be about 2 percent. Many projects require a much higher IRR, so growers should use their own scenarios to estimate their project benefits using the online spreadsheet. Annualizing the NPV gives us an equal annual income (EAI) value of -\$16. The EAI compared to an annual rental on the land (or an annual crop, such as corn) expresses NPV as an annual return.

Does this mean that you should not grow willow? Not necessarily. But it does mean that you need to take a careful look at your situation and costs since the suitability of willow as bioenergy can vary from farm to farm.

## Summary

Willow is one of the fastest-growing short-rotation woody crops in this region, and it can have relatively lower management costs than other energy crops. The total revenues and costs were purposely kept conservative in this budget scenario. It is expected that actual projected returns will be more positive and meet growers’ expected minimum returns. Any payback period can be shortened, especially if cost-share monies are available for planting costs and/or prices

per ton or yields per acre are higher. USDA cost-share programs such as the Biomass Crop Assistance Program (BCAP) can provide up to half of the growing costs. Carbon sequestration and energy savings from not using fossil fuels is another potential benefit of willow that may produce “carbon payments” to growers.

## Using the Spreadsheet

This scenario was developed to show the different costs and revenues involved in growing willow. The spreadsheet format shown below can be downloaded from [extension.psu.edu/natural-resources/energy/field-crops/resources](http://extension.psu.edu/natural-resources/energy/field-crops/resources) and adapted to fit specific grower conditions. You can change the quantity of inputs and their respective prices, allowing you to adapt costs and revenues to your situation.

## Table Footnotes

1. Based on per-year cost for activity in harvest years 7, 10, 13, 16, 19, and 22.
2. Net present value shows the discounted value over the production period. User can adjust the interest rate.
3. No phosphate or potash applications necessary unless test results show an extreme deficiency.
4. Lime is required unless pH is below 5.5.
5. Grid sampling in 5-acre units every 3 years (applied).
6. SureGuard applied at 6 ounces dry per acre; Transline at \$16 per acre; and Assure II at \$7 per acre.
7. Custom rates from Penn State Extension using USDA-NASS data (2014).
8. Based on using New Holland 9000 series forage harvester and FB-130 coppice header.

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