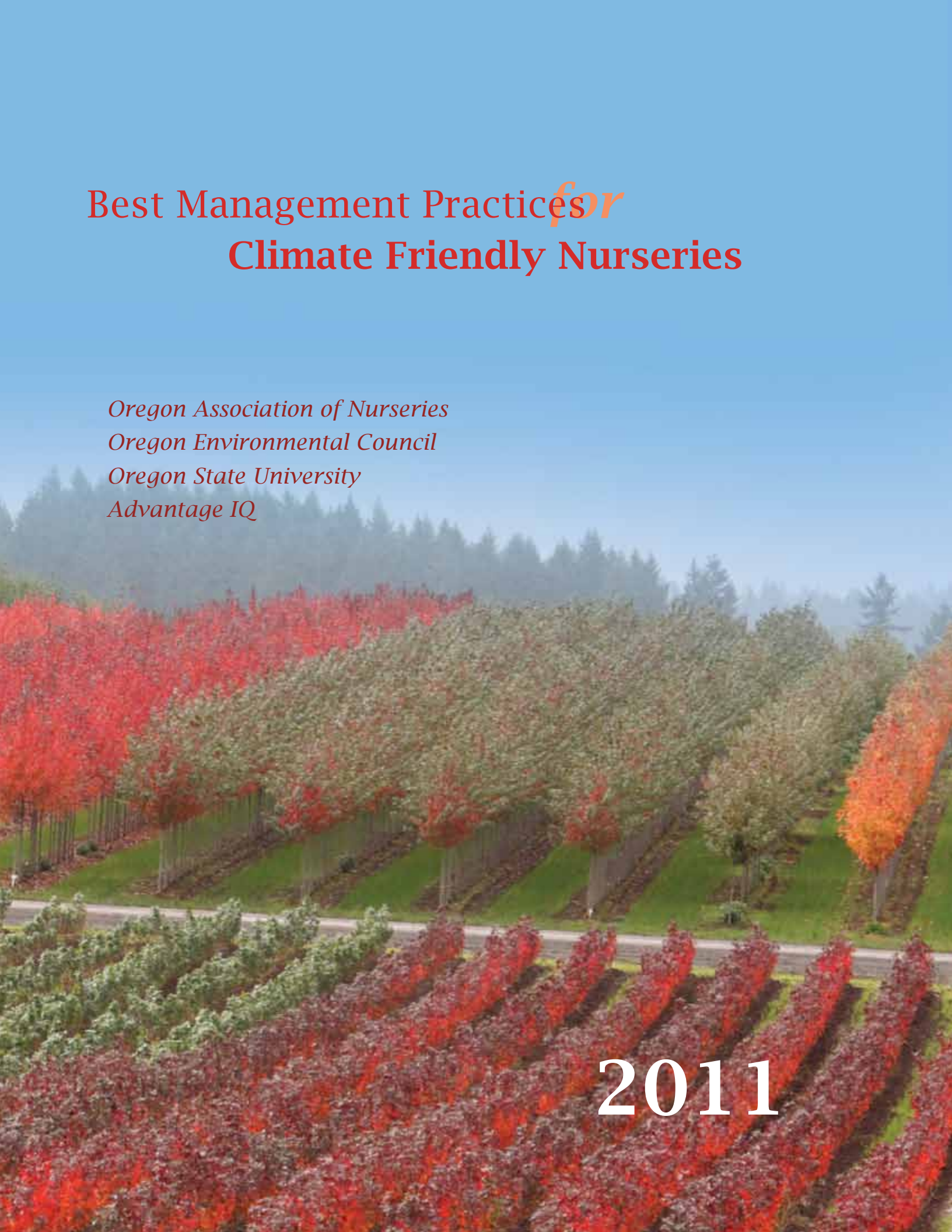
Best Management Practices *for* Climate Friendly Nurseries

Oregon Association of Nurseries
Oregon Environmental Council
Oregon State University
Advantage IQ



2011

Best Management Practices *for* **Climate Friendly Nurseries**

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Version 2.0, August 2011

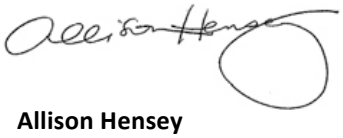
This guide was developed as part of the Climate Friendly Nurseries Project (CFNP), a collaborative partnership between the Oregon Association of Nurseries and the Oregon Environmental Council. The first of its kind in the nation, the project's central goal is to help participating nurseries reduce energy, resource inputs and greenhouse gas (GHG) emissions while achieving greater economic efficiency and profitability. Advantage IQ and Oregon State University serve as invaluable resources for the CFNP, both bringing research expertise and technical assistance that benefit participating nurseries. This guide provides:

- Recommendations for best practices that will reduce your energy and resource use, reduce costs, and at the same time, make your nursery more climate-friendly
- Case studies of Oregon nurseries that have already implemented these best management practices
- An overview of incentives to help nurseries pay for resource efficiency improvements

We hope you find this guide a valuable resource, and encourage you to find more resources and information about operational efficiencies that protect our natural resources at www.climatefriendlynurseries.org. On this website, you'll find tools to help you track your energy and resource use and calculate potential return on investment for best management practices (BMPs). We'll continue to add information about additional BMPs to the website as they are developed.

We welcome feedback about the guide, and encourage you to share your nursery's experience with efficiency improvements on the website.

Jeff Stone
Executive Director
Oregon Association of Nurseries



Allison Hensey
Oregon Environmental Council

For additional information regarding the Climate Friendly Nurseries Project, go to www.climatefriendlynurseries.org, or contact:

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Introduction

We are pleased to present this Best Management Practices Guide for Climate Friendly Nurseries, compiled as part of the Climate Friendly Nurseries Project (CFNP). The CFNP is an innovative effort that rose out of a collaborative partnership between the Oregon Association of Nurseries and the Oregon Environmental Council, and is an additional step in the nursery industry's work to proactively address natural resource issues. The first of its kind in the nation, the CFNP's central goal is to help participating nurseries reduce energy, resource inputs and greenhouse gas (GHG) emissions while achieving greater economic efficiency and profitability. Advantage IQ and Oregon State University also serve as invaluable resources for the CFNP, both bringing research expertise and technical assistance that benefit participating nurseries. Through the CFNP, participating nurseries quantify their energy and resource use and GHG emissions, and identify specific ways to reduce both. The project team also helps participating nurseries identify grants, low interest loans, and tax credits for energy and resource efficiency upgrades, and technical resources to assist with the upgrades.

The nursery industry is a proactive and innovative one, and many nurseries have already implemented practices that have had a positive impact on their environmental footprints. In addition, Oregon has a relatively clean fuel mix for grid-based energy, causing nurseries' energy-related emissions to be lower than they would be in other regions of the country.

Still, there are always additional opportunities for nurseries to take advantage of when looking for ways to reduce both their environmental impacts and the associated operational costs. The management and reduction of resource consumption and GHG emissions is a long-term process that achieves the following strategic objectives:

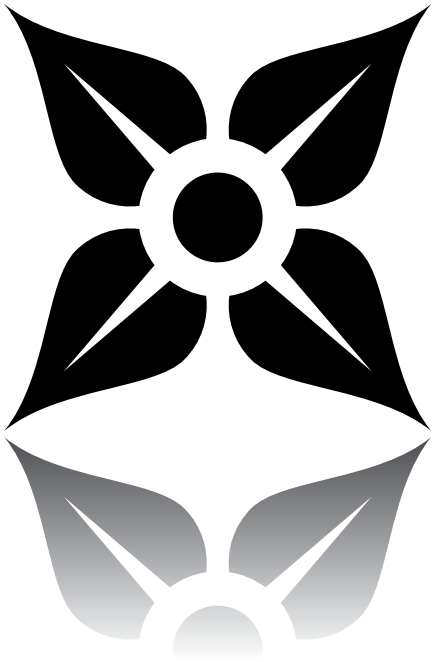
- Increase nurseries' understanding of resource-related costs, giving them more information with which to make informed business decisions, increase efficiency and reduce overall operational costs
- Proactively reduce operational GHG emissions and resource consumption
- Enable nurseries to be leaders on climate change in Oregon and beyond

The Best Management Practices Guide for Climate Friendly Nurseries is intended to assist all nurseries with these goals. The guide contains the following sections:

- GHG Basics. A short tutorial on GHG emissions and some of the major emission categories affecting the nursery sector.
- Best Management Practices. Seven best management practices that, when implemented, possess considerable resource and financial savings for nurseries. These measures were chosen for their applicability to the nursery sector, and by assessing the level of opportunity in terms of energy and GHG reduction for the costs associated with their implementation. These practices have good investment value for many nurseries, and are described in detail, including estimated costs and savings.
- Case Studies. An examination of several nursery participants of the Climate Friendly Nurseries Project. In these case studies, we depict their experience implementing some of the best management practices described in this guide. In these case studies, nurseries describe implementation successes and challenges, as well as lessons learned and where measured, savings captured.
- No-Cost/Low-Cost Opportunities. A list of efficiency measures that nurseries can implement with very little or no cost to their operations.

- Opportunities Requiring Upfront Capital. A list of best management practices that require upfront capital to implement, but that have good GHG reduction and savings potential for the nursery industry.
- Incentives and Rebates. Detailed information regarding the grants, tax incentives and rebates available to businesses implementing recommended best management practices.
- Next Steps. A discussion of the steps that nurseries can take to move towards project implementation including the use of savings calculators and onsite audits to determine project viability and payback.

It is our hope that this guide will not only be used as a tool in the decision-making process for those of you who wish to implement efficiency measures, but that it will also act as a catalyst for nurseries to share practical experience with your colleagues and discuss results of previously implemented best practices. There are a multitude of opportunities that nurseries can profit from while reducing their companies' resource consumption and GHG emissions. This guide contains new best practices, case studies, and updated incentive information. You can find the most up-to-date information regarding this guide and the Climate Friendly Nurseries Project at www.climatefriendlynurseries.org.



Greenhouse Gases: The Basics

Gases that trap heat in the atmosphere are called greenhouse gases. Some greenhouse gases (such as carbon dioxide, or CO2) occur naturally and are emitted by both natural processes and human activities, while other greenhouse gases are created and emitted only through human activities. According to the U.S. Environmental Protection Agency (EPA) and the Intergovernmental Panel on Climate Change (IPCC), humans have significantly increased the total amount of greenhouse gases in the atmosphere during the past century by burning fossil fuels such as coal, natural gas, oil and gasoline to employ cars, factories, utilities and appliances and through other activities. The gases emitted from these activities are enhancing the natural greenhouse effect, and likely contributing to an increase in global average temperature and related climate changes.

GHG Emissions in the Agricultural Industry

In the United States, the agriculture industry comprises 7 percent of the national GHG inventory; this figure primarily includes: (1) the result of soil management, commercial fertilizer, and manure use on croplands, which are nitrous oxide (N2O) emissions and approximate half of agricultural industry emissions; and (2) enteric fermentation (taking place during the digestive process of U.S. livestock) and manure management; these are methane (CH4) emissions and approximate the other half of the 7 percent of GHG emissions attributed directly to the agricultural industry. Clearly only the first category relates directly to nurseries. It is important to understand that the 7 percent figure does not include energy, transport, or inputs manufactured off-farm that are used by nurseries. These sources are attributed to other sectors such as energy, transportation and manufacturing in national GHG accounting to avoid double counting. However, these emissions sources still present excellent opportunities for operational efficiencies and GHG emissions reduction for nurseries.

The best opportunities for operational efficiencies, cost savings and GHG emission reductions in nursery operations include those related to:

- Soil management
- Nutrient use efficiency
- Fuel consumption for mobile and stationary combustion
- Electricity consumption
- Refrigerant use
- Freight transport
- Purchased goods and services, such as the use of plastic containers
- Waste management strategies
- Onsite water treatment
- Business travel
- Employee commuting

Currently, there is no Northwest specific data on GHG emissions and opportunities for reductions by Northwest nurseries. We hope this project will begin to provide that information. However, in the meantime, we look to other areas for useful information to inform our efforts to reduce costs and environmental impact. While it includes regional emissions factors that do not pertain to the Pacific Northwest, the Australian government has done some interesting work in measuring GHG emissions in horticulture as a whole. They recently reported the following as the key sources of direct and indirect emissions for the horticulture industry:

- 70 percent of total emissions result from burning fuels in vehicles, farm machinery and pumps, and electricity usage
- 20 percent of total emissions result from nitrogen fertilizer and animal manure application
- 10 percent resulting from waste and refrigerant loss

GHG Sequestration and the Agricultural Industry

In the U.S., the agricultural industry sequesters approximately 44 MMTCO2e (million metric tons of CO2 equivalents) annually (2003-2007 average). However, operational emissions averaged 514 MMTCO2e over the same period; therefore, the agricultural industry is a net emitter. Importantly, there are multiple opportunities to enhance carbon sequestration within the agricultural industry. One key area for improvement is soil management. A recent study by the USDA and EPA estimates that annual carbon sequestration opportunities in the agricultural industry range from 590 to 990 MTCO2e per year, which could offset the national annual inventory by 8 percent to 14 percent.

However, it is important to note that a degree of scientific uncertainty remains with some soil management sequestration plans. This uncertainty begins with the classification of soil sequestration as indirect or biological sequestration, which is part of the short-term carbon cycle. In short-term cycles, natural processes of photosynthesis and carbon sequestration in plants and respiration in plants and animals maintain a balance of oxygen (O) and carbon dioxide (CO2) in the atmosphere. Natural absorptions of CO2 approximately balance natural emissions . In comparison, burning fossil fuels disrupts the natural equilibrium in short-term carbon cycles because they add an excess of CO2 into the ecosystem. Carbon in fossil fuels is not part of the natural carbon cycle; when these fuels are burned, the CO2 emitted is in addition to the CO2 cyclically being emitted and sequestered from natural sources .

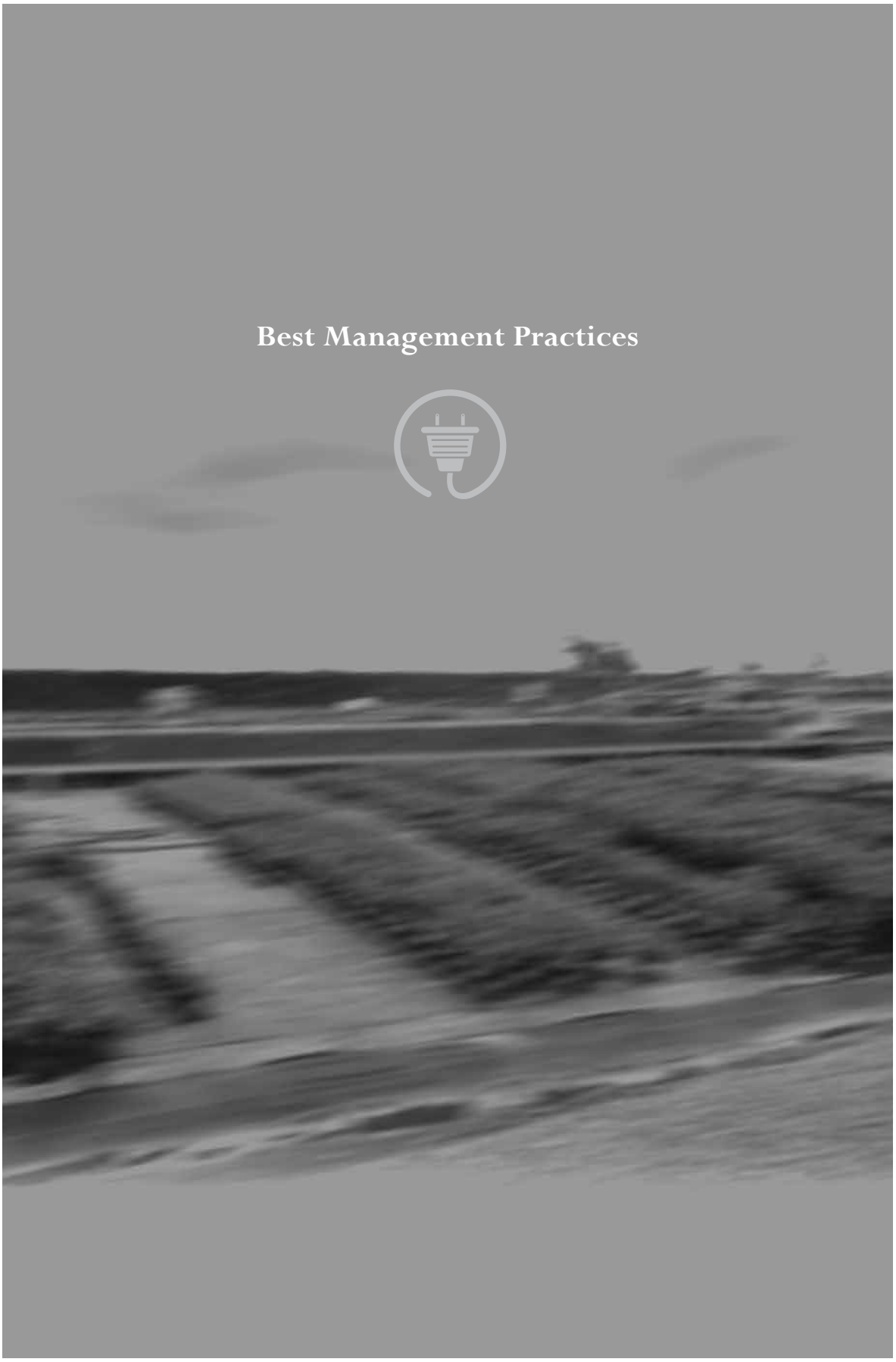
On a positive note, soil management sequestration plans have the potential to increase carbon sequestration beyond levels naturally occurring in the short-term cycle and to have a positive benefit on the overall equilibrium by nullifying a certain portion of the excess CO2 derived from fossil fuel consumption. However, the level of impact is complicated to calculate because there are so many site-specific factors to take into account; location, climate, soil type and tillage practices will all have a substantial impact on the level of carbon sequestration occurring.

In an effort to investigate the topic further, the U.S. Department of Agriculture (USDA) recently funded the National Soil Dynamics Laboratory (NSDL) research project specific to the horticulture industry aiming to identify horticultural management practices which lead to reduced GHG emissions as well as enhanced carbon sequestration. The complete findings from this work will be available in 2014.

Greenhouse Gas Reporting

The process of creating an annual GHG inventory provides companies with information regarding the activities that cause emissions, allowing them to focus on those activities with the largest impact. You can't manage what you don't measure. Annual GHG reporting in the U.S. is standardized in the U.S. by The Climate Registry (www.theclimateregistry.org). To learn more about GHG accounting, and use the Climate Friendly Nurseries Project's downloadable GHG Inventory Tool for nurseries, go to www.climatefriendlynurseries.org.

Best Management Practices



1. Efficient Lighting

Description

Lighting upgrades are the easiest first step in any energy efficiency program and can payback investment costs through energy savings in as little as two years or less. New bulbs and fixtures last longer which means less maintenance and associated labor costs. Occupancy sensors provide energy savings by automatically shutting down lighting applications when rooms or particular areas are vacant. Both lighting upgrades and occupancy sensors usually make financial sense as they require low capital investment but have fast paybacks, and should be examined separately in warehouses, offices, and grow light applications.

Recommended Measures

Upgrade

Lighting upgrades tend to be one of the simplest and most direct ways to save energy and see tangible electricity bill savings. An average incandescent bulb lasts one or two years and consumes 66 kWh per year; an average compact fluorescent lamp (CFL), alternatively, lasts six years and consumes 16 kWh per year, bringing an average cost savings of $5 per bulb per year in electricity charges. In addition, maintenance costs are far less for efficient lighting, since bulbs last up to ten times longer, and fixture hardware tends to last an average of twenty years. Likewise, the conversion of any halide lights or T12 fluorescent lamps to T5 or T8 lamps will capture substantial electricity savings.

Install Occupancy Sensors

The installation of motion sensors, or occupancy sensors, is also strongly recommended. Motion sensors have integrated adjustable timers that automatically turn off the light fixture when no motion is detected. Since this feature is integrated into each fixture, the light in occupied areas will remain lit, while those in unoccupied portions of the same space will turn themselves off – automatically saving energy. Burn time is generally reduced by approximately 25 percent when utilizing occupancy sensors.

Additional Benefits and Considerations

Performing lighting upgrades provide multiple benefits. First, in many cases the quality of lighting improves. Second, the lifetime of more efficient bulbs is typically much longer (7 to10 times) than that of inefficient lighting; this extended lifetime allows for reduced maintenance and labor costs. Third, lighting retrofit analysis can also examine possibilities to reduce, or “delamp,” the number of lighting fixtures employed, further reducing lighting load and quickening the payback.

Occupancy sensors require thoughtful consideration of the most appropriate application. For example, occupancy sensors in high-bay applications may not trigger the device when required as the sensors are located at a great distance from typical motion. Also, installing an occupancy sensor with the sensitivity at its highest setting may unintentionally cause the device to turn on for cats and other animals. In general, sensors with light sensitivity (those able to detect when incoming natural light is sufficient) and located in facilities or areas with intermittent activity are ideal.

Where do I start?

1. Contact your local utility to understand current lighting incentives and training opportunities. If in Oregon, Energy Trust of Oregon is a useful resource.
2. Find a contractor near you. Energy Trust of Oregon trade allies—http://energytrust.org/library/find-a-contractor. Other public utilities use BPA trade allies—http://northwest-lighting.org
3. Schedule onsite assessment.
4. Get quote and understand project cost and available incentives (Energy Trust or utility + State of Oregon's Conservation Tax Credit).
5. Talk to someone who's done it. See case studies at www.climatefriendlynurseries.org
6. Consider applying for additional incentives such as USDA's Rural Energy for America Program. Apply for applicable incentives BEFORE you begin. www.rurdev.usda.gov/or/reapee.htm
7. Set up installation to work with your production cycle.

Recommended Tools

- Oregon State University Energy Efficiency Center: eeref.engr.oregonstate.edu/EEREF_Energy_Efficiency_Reference/Opportunities_with_Calculation_Sheets/Building_Day_Lighting
- Additional tool recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

Lighting Retrofit and Occupancy Sensor Installation

	40-acre Nursery	400-acre Nursery
Cost (before incentives)	$1,450	$7,200
Incentives*	$1,408	$6,837
Energy Trust of Oregon	$665	$3,147
Oregon Business Energy Tax Credit	$380	$1,890
USDA Rural Energy for America Program Grant	$363	$1,800
Annual Savings	$441	$2,919
Payback	<1 year	<1 year

* Examples are based on financial incentives currently available in Oregon. Many states have similar programs. Opportunities for efficiency improvements are site specific and vary.

Next Steps: Lighting Upgrades and Occupancy Sensors

- Transition T12 lighting to T8 lighting in all warehouse facilities. This upgrade creates the most energy savings and the fastest payback.
- Replace all incandescent lights with CFLs. The labor budget for installing and maintaining CFLs is significantly lower than other retrofit options; the transition can be performed by staff.
- Examine possibilities to "delamp" wherever possible; remove lamps if the current level of lighting is not required. With the transition from T12 to T8 lighting, it is common to reduce the number of lamps being used, as T-8s offer greater illumination than T12s do.
- Install occupancy sensors in warehouses. This is the best opportunity for capturing savings at a nursery, as the estimated annual operating hours are reduced from 2,600 hours to 2,000 hours.
- Low-cost but lower energy savings are available with the installation of occupancy sensors in office areas.
- Energy Trust of Oregon bonus lighting incentives expire November 1, 2011. Oregon's Business Energy Tax Credit has now become the Oregon Conservation Tax Credit.

Blooming Nursery, Inc.: the 'Easiest Sustainable Project on their Docket' – Lighting Upgrades and Controls

Blooming Nursery

By Whitney Rideout, Oregon Association of Nurseries (2010)

Go to Blooming Nursery, Inc. in Cornelius, Oregon and you'll find yourself immersed in a culture thriving on progressive and sustainable practices. You'll find everything from LiveRoof® modular green roof system and solar thermal panels to restored riparian areas and container recycling programs; very alluring and cutting edge stuff. But in this case study we're going to focus on lighting upgrades. Why? Simple. This series of studies is intended to help nurseries get started on sustainable practices in a challenging economy. Lighting upgrades provide a very simple and profitable project with a short payback period. In other words, this is: 'Sustainability on Training Wheels' and it can start contributing savings to boost your bottom-line sooner than you might think. Moreover, Blooming Nursery has done a brilliant job with their lighting upgrades, so if you're looking for a way to get started on a sustainability effort - here is your blueprint on a silver (and green) platter.

Blooming Nursery, Inc. (Blooming) is a wholesale nursery that provides more than 1,800 perennials, flowering shrubs, herbs, ground covers and ornamental grasses. They offer finished containers marketed under the Blooming Advantage name as well as plugs, potted liners and bare root divisions. They cultivate most of their plants in a state-of-the-art 40,000 square foot propagation greenhouse, which can then be moved into heated greenhouses totaling 60,000 sq ft, or to 150,000 sq ft of cool greenhouses and cold frames. They also maintain over 45 acres of growing fields to support their bare root offerings.

Michael Wisshack, General Manager for Blooming, was kind enough to showcase all the sustainability projects they have underway, including energy efficiency items. When Blooming decided to increase their energy efficiency, they began by replacing inefficient boilers with high efficiency condensing boilers and installing heat retention curtains in propagation areas. Lighting seemed a natural next step, and they dug into the project with an intelligence and thoroughness that made short work of it and actually wound up getting most of it paid for by government incentives and grants; more on that in a moment.

[Wisshack] “Lighting was actually the simplest of the actions we implemented in that timeframe. Energy Trust of Oregon (ETO) performed an onsite-audit for free, and wrote up a detailed lighting analysis - it was very impressive and enlightening to see the kind of money we were leaving on the table due to our legacy lighting systems.” The ETO analysis described Blooming’s energy use, suggested upgrades, and included a full ROI analysis which detailed estimated payback of the upgrades, including the amount of work that could be funded through ETO incentives and Business Energy Tax Credits (BETC).

[Wisshack] “79 percent of the project was paid for by available incentives, which of course was wonderful as this took the ROI payback timeframe down to a year.”

Recommendations by ETO included:

Blooming retrofitted lighting in their barn, offices, shop and lunch room.

- Replacing existing T12 lights with T8 lights: T12 lamps are the very common 1 ½” diameter fluorescent tube lamps. T8 lamps are 1” diameter and also fluorescent tube, but use less electricity and produce more light than T12 lamps. Blooming replaced 40 T12 fixtures.
- Replacing Metal Halide lights with T8 lights. Metal halide lamps are common in high-bay applications such as warehouses or barns. Blooming replaced 13 metal halide lamps with 6-bulb T8 fixtures, cutting electricity use in half in those areas.
- Installing lighting controls: installation of occupancy sensors to ensure lights are turned off. Occupancy sensors were installed on individual fixtures. This allows some lights in a room to be on while others can remain off if that area is not occupied. Occupancy sensors can increase electric savings by 25 percent or more.

[Wisshack] “ETO made this project very easy because they did the analysis and even provided a list of contractors to make the upgrades. Scheduling the contractors to change the fixtures was the most difficult part of this project that we had to manage, but it wasn’t really burdensome as the contractors were very flexible and did most of the work during off times to help alleviate the stress and inconvenience on staff and better facilitate our production demand.”

[Wisshack] “What can I say - it was just a great experience. No training was needed, our lighting is better, and our electricity bills are lower. We now save almost $2,200 per year in electricity and offset 11 tons of CO2. So, it’s good business, and it also feels good to know that we’re fundamentally better stewards of the resources we use to do our jobs and serve our customers. The project was simple and the payback (after incentives) of one year makes it something every nursery operation should investigate.”

2. Variable Frequency Drives (VFDs)

Description

Variable Frequency Drives (VFD) enable irrigation pump systems to work only at the rate necessary in order to complete the job for which they are responsible. Installing a VFD on a system reduces the rotational speed of the motor, which then decreases the speed of the pump, allowing it to consume exactly the amount of power required for use. Installing VFDs will capture substantial energy savings (20 to 50 percent). For information about water savings benefits, see the case study on Eshraghi Nursery that follows.

Recommended Measure

Install VFDs on all Relevant Irrigation Pumps

Whether or not the installation of a VFD is operationally and financially appropriate depends upon the following conditions: 1) if the irrigation pump is required to operate with varying flow and pressure needs; 2) if the pump must operate at varying well depths; and 3) if the pump is oversized for the required task. If any three of these factors are present, then the installation of a VFD should make both financial and operational sense.

Additional Benefits and Considerations

There a multitude of operational benefits to a VFD that will tangibly reduce maintenance costs, including: soft-start up, auto restart, remote starting and even pressure.

Incentives Available

Please refer to www.climatefriendlynurseries.org for detailed information regarding incentives from the following entities that apply to VFD installation:

- Energy Trust of Oregon (ETO)
- Bonneville Power Administration (BPA)
- US Department of Agriculture Rural Energy for America Program (REAP)
- State of Oregon's Conservation Tax Credit

Recommended Tools

- The U.S. Department of Agriculture, Natural Resources Conservation Service's Energy Estimator: ipat.sc.egov.usda.gov/
- Oregon State University Energy Efficiency Center: eeref.engr.oregonstate.edu/EEREF_Energy_Efficiency_Reference/Opportunities_with_Calculation_Sheets/Low_Pressure_Irrigation

Additional tool recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

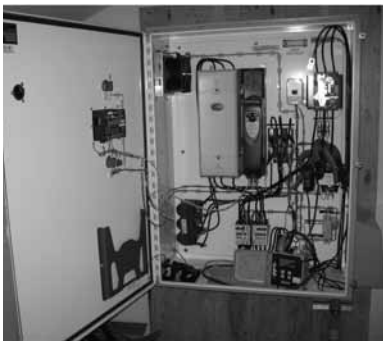
Variable Frequency Drive Installation on Irrigation Pumps		
	40-acre Nursery	**400-acre Nursery**
Cost (before incentives)	$9,500	$49,500
Incentives*	$6,069	$37,169
Energy Trust of Oregon	$1,200	$11,800
Oregon Business Energy Tax Credit	$2,494	$12,994
USDA Rural Energy for America Program Grant	$2,375	$12,375
Annual Savings	$755	$8,706
Payback	~4.5 years	~1.5 years

*Examples are based on financial incentives available in Oregon as of March 2011 and are subject to change. Many states have similar programs. Opportunities for efficiency improvements are site specific and vary.

Next Steps: Variable Frequency Drives

- Assess whether a VFD makes sense for your system (varying flow, pressure, and well depth; oversized for application).
- Compile an inventory (make, model, HP, application) of irrigation pumps. Investigate with ETO if your pumps are eligible for substantial incentives.

Eshraghi Nurseries LLC Found Energy, Water and Cost Savings by Installing VFDs on Their Well Pumps



Eshraghi Nursery

By Allison Hensey, Oregon Environmental Council (2010)

You wouldn't keep your car in fifth gear to drive around town – you'd shift to a lower gear so that your motor isn't working any harder than it has to. Variable Frequency Drives (VFDs) are the same principle – they allow a motor to shift to a lower gear, and only work as hard as needed to do the job. This means saving energy, energy costs, and greenhouse gas emissions associated with energy use. When you install a VFD on an irrigation pump, it also enables you to match water volume to plant needs, rather than being stuck with one speed for watering - high, which benefits plant health and saves precious water resources.

Eshraghi Nurseries LLC is a family-owned wholesale grower in the beautiful Willamette Valley specializing in Japanese maples, grafted conifers and woody ornamental nursery stock. They're celebrating their 20th anniversary this year.

Eshraghi draws irrigation water for their nursery from ponds, wells and the Tualatin River. In early summer 2010, Eshraghi installed its third VFD on a 50-horsepower well irrigation pump. Eshraghi will receive one-third of its $8,000 capital investment in a VFD back through a tax credit next year, as well as incentive funds for half of the upfront cost from Energy Trust of Oregon. With these funds, Eshraghi believes that its up-front investment will pay back within approximately 8 months based on an anticipated 50 percent annual energy savings from the VFD. The nursery estimates that it also spent an additional $5,000 in time and labor for system design.

Additional benefits from the VFD include being able to match water use to water needs, which benefits plant health and growth and saves water. Avoiding future pump maintenance issues is also an anticipated benefit of the VFD, as it will allow multiple low volume uses of water without risking pump blowout.

Chris Lee, Farm Manager with Eshraghi Nurseries LLC, said that there was a fine-tuning period for a few months with the second VFD pump they installed, but the computer technician from Hillsboro Pump was very responsive in helping them calibrate it to meet their needs, and now it's working perfectly. Nurseries should also know that there is an override on VFDs that allows manual operation should it be needed. Lastly, Chris recommends that nurseries install VFDs when they are not irrigating as VFD installations can take irrigation off-line for several days.

3. Irrigation Efficiency

Description

Clearly, plant irrigation is a significant component of nursery operations in terms of employee hours, resource consumption, and operational cost. In the agricultural industry, an average of 30 percent of all energy consumed is used by irrigation systems. This percentage may be lower for nurseries, given energy use for heating and cooling greenhouses; however, the energy required for irrigation is still significant within the nursery industry. Configuring irrigation systems in a manner that ensures proper care for nursery products while limiting wasteful use of water and energy will lead to financial savings, potentially offer better care to plants than less efficient systems do, and will also reduce GHG emissions related to energy use and from the application of fertilizers. Due to the variability of product, type and configuration and size of nursery operations, irrigation requirements for nurseries vary considerably throughout the industry. All irrigation systems, however, will benefit from attention to a number of factors that affect system efficiency:

- **Irrigation System Design.** The irrigation system should be designed to ensure the pump produces proper feet of head within a given pump efficiency, compensates for changes in elevation, has appropriate pressure critical points or nozzles, and is broken to adequate number of zones with manageable flow rates. The system should also be designed to ensure the appropriate level of interception and application efficiency.
- **Application Rate and Uniformity**. It is recommended that all nurseries calculate application rates for specific zones, and that they periodically assess application rates and irrigation uniformity using strategically placed catch-cans.
- **Irrigation Scheduling.** Irrigation management of nursery crops grown in containers can be difficult to assess because of the numerous factors that are challenging to account for on a day-to-day basis including weather, substrate, crop water use, crop canopy architecture, irrigation type, precipitation rate, irrigation distribution, and irrigation efficiency. While it is a valid approach to choose a coarse substrate that will allow for overwatering without affecting plant health, excessive watering will negatively impact operational costs relating to water, energy to run pumps, and applied nutrients that get washed away before being absorbed by the plants. It is therefore recommended that nurseries utilize leaching fraction calculations as well as individual crop water use and relative crop evapotranspiration guidelines to effectively schedule crop irrigation.

For additional information regarding these measures, including the calculations that can be used to derive system efficiencies, please see “Irrigation Strategies to Conserve Water in Container Nurseries”.

Recommended Measures

Schedule Irrigation

Irrigation scheduling is a relatively low-cost measure that, as a rule of thumb, can reduce water consumption by 30 percent. Importantly, reducing water consumption leads to a reduction in the energy used to pump from ponds and wells as well as energy required to pump water for recycling and treatment.

Install Drip Irrigation System

Conversion to drip irrigation will drastically reduce the amount of water required for crops. However, the upfront capital cost of drip irrigation systems is significant and other benefits aside from reduced energy and water consumption need to be assessed.

Additional Benefits and Considerations

While irrigation scheduling is typically a low-cost measure, there are times where more costly investments for sensors and subscriptions to a scheduling service may be most appropriate for your operations. Also, irrigation scheduling can increase staff cost and time, especially at the beginning when new schedule systems are being learned.

Drip irrigation has multiple benefits other than water and energy reduction:

- Reduced use of fertilizer
- More precision in the application of water
- The ability to fertigate/chemigate
- Reduced soil erosion
- Reduced labor costs

Incentives Available

Energy Trust of Oregon has the following incentives available for common fixtures and controls:

Measure	Incentive Range
Irrigation System Conversion	Up to 40% of energy savings by converting to drip irrigation; up to 50% energy savings by converting to a linear/pivot irrigation system
Sprinklers, Nozzles, and Gaskets	$1 to $3 per part for linear and pivot improvements; $.25 to $8 per part for wheel and hand-line improvements

Where do I start?

1. Schedule irrigation early in the day to avoid water loss through evaporation.
2. Check soil moisture to reduce overwatering of plants and nutrient loss.
3. Repair or replace broken sprinkler heads, gaskets and leaking pipes.
4. Perform regular maintenance on pumps.
5. Contact your local utility to understand current lighting incentives and training opportunities. If in Oregon, Energy Trust of Oregon is a useful resource or your local utility to understand current irrigation incentives and training opportunities.
6. Find an irrigation specialist near you.
   Energy Trust trade allies—http://energytrust.org/library/find-a-contractor
   Other public utilities use BPA partner Cascade Pacific RC&D – www.agenergynw.org
7. Schedule onsite assessment. Efficient irrigation begins with good system design.
8. Get quote and understand project cost and available incentives (Energy Trust or utility + State of Oregon's Conservation Tax Credit).
9. Talk to someone who's done it. See case studies at www.climatefriendlynurseries.org
10. Consider applying for additional incentives such as USDA's Rural Energy for America Program and/or NRCS programs such as EQIP. Apply for applicable incentives BEFORE you begin.

Potential Savings

Overhead Irrigation Scheduling		
	40 Acre Nursery	**400 Acre Nursery**
Cost (After Incentives)	$400	$2,800
Annual Savings	$760	$7,000
Payback	~7 months	~5 months

Next Steps: Irrigation Efficiency

- Determine irrigation uniformity and whether irrigation system maintenance or altering system design is warranted to move uniformity into acceptable ranges.
- Identify current interception efficiency of overhead irrigated plants and consider spacing method and/or conversion to drip irrigation to maximize effective water use.
- Determine leaching fraction or application efficiency to see the effect of crop water use, substrate, container size, crop growth stage, and canopy architecture.
- If not currently scheduling irrigation, begin to use one of the given tools described in "Irrigation Strategies to Conserve Water in Container Nurseries" at www.climatefriendlynurseries.org to begin improving irrigation scheduling. If already using the given tools, talk to allied suppliers about new technology that can further enhance irrigation scheduling.

J Frank Schmidt & Son Co.: Using Drip Irrigation to Save Money and Resources

A variety of filtration technologies are employed to remove contaminants unique to each water source. [Doane] "Our largest filter station is connected to a central pond that holds water from a well. Water is pumped from the pond, treated for algae by injecting a low concentration of chlorine, mechanically scrubbed to remove particulates, and then finally distributed to mainline at rates that can reach 2,000 gallons a minute at peak flow."

By Whitney Rideout, Oregon Association of Nurseries (2010)

Water, labor and energy all play a role in nursery irrigation. J Frank Schmidt & Son Co. (JFS) took progressive measures to install underground drip irrigation at two of their farms, and by so doing, harvest savings and time benefits. The installation of drip irrigation offered an additional opportunity - drip fertigation – which reduced another costly input and diminished the chance for fertilizer to leach out of their farm and into water systems.

When I stopped by the JFS Canby, OR site one very rainy day in May 2010 to talk to Sam Doane, Production Horticulturist, I thought it would take an hour to talk about the system, a few minutes to take pictures and then back on the road. Like many systems in a large organization it turned out to have more depth than I anticipated. This case study is far from comprehensive; establishing reliable and trusted drip irrigation and fertigation took many years, diligence, research and patience, and the farm is still working on system improvements. This is an introduction with more in-depth information following in future case studies.

PART 1: Underground Drip Irrigation

Water, labor and energy all play a role in nursery irrigation, but it was the second variable – labor – that compelled JFS to proceed with an underground drip irrigation project. JFS had already used many techniques to mitigate irrigation costs: comprehensive schedules and field methods like soil monitoring to water on an as-needed basis, and installing a more efficient and effective system was the next logical step. In 2000 when Sam Doane was transferred from JFS's farm in Independence to manage the farm in Canby, the minimum wage was rising and Oregon was already above the national average. (In 1997 lawmakers increased the federal minimum wage to $5.15/hour; in 2007 this was raised again to $7.25/hour. By comparison, in 1997 Oregon's minimum wage was $5.50/hour and by 2007 Oregon's minimum wage had risen to $7.80/hour, [Doane] "We were paying a lot of overtime for workers to move irrigation pipe and finding a way to mitigate this rising expense was a key priority. Above-ground irrigation is incredibly labor intensive, we were often operating from 5 am to 9 pm."

Doane looked into underground drip irrigation and created a labor savings analysis that captivated JFS owners. [Doane] "The ROI (return on investment) for the infrastructure costs was two years: three workers could do the work that a crew of up to sixteen did before, and there was a 30 percent reduction in water use at the end of the third year when the system was fully fleshed out."

With this type of ROI analysis Doane received permission to start a pilot project at the Canby, OR facility – a 1,200-acre bare-root shade and flowering tree farm. The project was implemented over a five year period. All of the mainline and filtration systems were installed in the first and second years. With each planting cycle JFS converted more acreage to drip irrigation until the entire farm was done.

Installation of the system was only the beginning of this project. The next step was to develop an irrigation schedule which would take into account soil type, root patterns, crop type, desired water cycle and age of plant. [Doane] "We started out using soil moisture-sensing technology, and in conjunction with this completed a two-year study with Rich Regan at Oregon State University to develop crop coefficients applicable to our diverse group of crops." The crop coefficients help refine data from the AgriMet stations; a subset of an overall satellite network of automatic agricultural weather stations which provides information for near-real-time management of water operations in the Pacific Northwest.

"The fields look different with drip irrigation - they are dry."

Any nursery operation considering drip irrigation needs to expect adjustments to expectations and operations. [Doane] "The fields look different with drip irrigation - they are dry. This was a major adjustment for everyone in the operation as we were used to seeing wet soil, and with that, came knowledge that the plants had enough water for the near future. When we installed the first 220 acres we think we actually used more water than before. The overhead system was limited by hours in the day, pump flow, and the amount of handline that we had available. The new drip irrigation system made completing our irrigation schedule an easy task, and because we were still building system confidence we ran the drip irrigation until we saw water on the surface. After reviewing many soil moisture charts we discovered that this was applying more water than is necessary and it defeated one of our goals – to reduce water use." JFS had been using gypsum blocks for decades to help schedule irrigation. With the change to drip irrigation, new irrigation feedback mechanisms needed to be implemented to ensure this task was completed accurately and effectively. JFS first used electrical sensors that uploaded data to a PC and provided instant feedback – 24/7. The instant feedback helped support the management team's contention that they were applying enough water. The monitoring device they elected to use after gaining a few years of watering confidence was the portable 'Diviner,' which can be taken to all access points at the facility; JFS transitioned from 24/7 monitoring to measuring soil moisture content at a point in time three times a week. [Doane] "That level of information – three data points a week - took time to get comfortable with. Nursery owners and managers need to experiment with different feedback devices and levels of detail that allow them to run their operations effectively."

This case study is very brief in relation to the effort that went into creating a system that delivers drip irrigation accurately and consistently. Before any operation considers drip irrigation there are some items to consider:

By fertilizing and watering at the same time, JFS reduced overall fertilizer use by 30 percent. The ROI on this project and system infrastructure was less than a year.

1. Hire an experienced engineer. Pay an expert to complete an analysis of the entire system. Everything from mainlines to filtration to flow and pressure, otherwise you could build a system that will not work the way it's intended. The goals are to save water, increase uniformity and efficiency, and make irrigation less burdensome – poorly designed systems won't help you achieve these goals.
2. Management commitment. The managers at JFS were excited about the prospect to reduce labor costs, however, without their forward thinking and commitment to the long-term profitability of the operation this project would have failed. There are many adjustments required for this type of change and management needs to buy in 100percent.
3. Confidence comes with time and experience. There will be many hurdles when installing and perfecting a system like this. If you are going to use a soil moisture monitoring system, make sure you have a staff member who can interpret and evaluate complex graphs and data that come with the system, and someone familiar with the irrigation requirements of your crops. Simple, non-technical solutions are available for evaluating soil moisture as well; these can be a good option during the learning process.
4. Fit the project with the property. JFS doesn't plan to use underground drip irrigation at their Monmouth farm because they've experienced problems with voles in the past. (Voles and other rodents can chew into drip systems, resulting in wasted water and excessive maintenance costs). Also, there are some crops which need the evaporative cooling of overhead watering (ash trees for example), so these types of crops may not be best suited for "drip only" irrigation.

[Doane] "The end product has been worth the effort; our operational efficiency has increased through reduced labor costs and water use, we are able to work and cultivate in a field while irrigating, and we have reduced weed growth by limiting surface water. Our owners are happy and we are taking steps to ensure our competitive advantage and future success."

PART 2: Reduced Fertigation Through Drip Irrigation

World fertilizer prices started rising in 2002 and reached historic rate increases in 2008. During the 12 months ending in April 2008, nitrogen prices increased 32 percent, phosphate prices 93 percent, and potash prices 100 percent. This price surge in 2008 was due to strong domestic and global demand for fertilizers, increased energy and freight prices, higher demand for grain-fed meat in emerging countries and low fertilizer inventories.

Rising fertilizer prices and changing perceptions about plant fertilizer needs compelled JFS to look into new and more efficient fertilizer application opportunities. [Doane] "We had already moved from broadcast to band application to reduce fertilizer use, but we couldn't water in granular fertilizer with drip irrigation. Injecting fertilizer, or fertigating, into drip ir-

rigation provided us with an opportunity to utilize the system to deliver fertilizer directly to the root zone. By fertilizing and watering at the same time, we reduced overall fertilizer use by 30 percent. The ROI on this project and system infrastructure was less than a year."

Doane said system set-up and design were pretty simple. [Doane] "We do manifold level injection 2 ½ to 5 acres at a time for our drip irrigation fields. The hardest part of the system was making sure we had the right dilution factor and keep salt levels where we were comfortable. We use a proportional injector to measure the amount of liquid fertilizer we are injecting; to help keep costs low, we installed this as a bypass on the manifold (about 10 percent of the water goes through the injector). We use a simple flow meter and a series of valves to set the flow at our desired level. We wrote an Excel calculator that allows the irrigation crew to input a number of variables, like row length and total flow per manifold, to ensure that injection rates remain at a safe level."

"We've reduced overall fertilizer use by 30 percent which is a win for everyone. Our operational costs are lower and we are responsible for fewer GHG (greenhouse gas) emissions normally attributed to nitrous oxide emissions. If anyone decides to implement a drip irrigation system, this is a natural next step to investigate."

4. Greenhouse Insulation

Description

Significant energy reductions are available by appropriately insulating greenhouses. The first step is to seal all air leaks in greenhouses. Once that measure is complete, more substantial investments should be considered. The most prominent examples are installation of thermal blankets or shade curtains. These curtains dramatically reduce the amount of heat that evaporates overnight. Combining thermal blankets with the insulation of unused greenhouse ends will form a solid foundation for an energy-efficient greenhouse.

Invest in GREENHOUSE EFFICIENCIES

- Install a programmable thermostat
- Replace single poly with two layers: one poly and one infrared poly
- Replace fiberglass with double or triple polycarbonate
- Install roll-up walls or roof vents for natural ventilation to minimize the need for fans
- Insulate sidewalls and unused ends
- Install a thermal curtain
- Upgrade to an energy efficient boiler
- Replace gravity vented heaters with power vented heaters or even better, with combustion air separated heaters or better still with condensing heaters
- Your best bet is to replace heaters with under bench heating – although it is expensive, it heats plants directly at the roots, has a long life, and uses the least amount of energy

Incentives Available

Energy Trust of Oregon has the following incentives available for upgrades to more efficient greenhouse materials.

Measure	Incentive $ Range
Infrared (IR) polyethylene greenhouse cover	$.02 per square foot of material purchased
Thermal curtain	$.09 per square foot

Recommended Tools

- US Department of Agriculture- Virtual Grower is a decision support tool for greenhouse growers where users can build a greenhouse with a variety of materials www.ars.usda.gov/Research/docs.htm?docid=19961

Additional tool recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

It is important to note that nurseries can insulate greenhouses slowly over time. To simplify the results, the numbers below assume that the nurseries implement the recommended insulation measures all at once.

Greenhouse Thermal Curtains and Insulation of Unused Ends		
	40-acre Nursery	**400-acre Nursery**
Cost (before incentives)	$5,625	$94,500
Incentives	$3,101	$52,256
Energy Trust of Oregon	$218	$3,825
Oregon Business Energy Tax Credit	$1,477	$24,806
USDA Rural Energy for America Program Grant	$1,406	$23,625
Annual Savings	$600	$10,935
Payback	~4 years	~5 years

* Examples are based on financial incentives currently available in Oregon. Many states have similar programs. Opportunities for efficiency improvements are site specific and vary.

Next Steps: Greenhouse Insulation

- A simple but very important measure is to seal all air leaks.
- Re-glaze when needed with triply polycarbonate.
- Consider wind barriers (for example, rows of evergreen trees) which can reduce outside air infiltration.

Northwoods Nursery/One Green World: Simple Greenhouse Insulation for Fuel and Cost Savings

Northwoods employees installing insulation.

By Allison Hensey, Oregon Environmental Council (2010)

Growing up, when the weather turned cold, instead of turning up the thermostat at home my Dad would tell me to put on a sweater. Greenhouse insulation is the same concept. Like most nurseries, Northwoods Nursery in Molalla uses propane to heat their greenhouses, making recent increases in propane costs a challenge. Northwoods Nursery decided to put a sweater on their greenhouses to keep the temperature comfortable for their plants, rather than pay higher energy costs.

Saving on propane costs can be as simple as sealing cracks and adding weather-stripping in a greenhouse as a first step. "One of our employees has been locating gasps in the greenhouse and sealing them to prevent heat loss," says Laura O'Leary, Sustainability Director for Northwoods Nursery.

The next step for the nursery was replacing single poly sheeting on all greenhouses with double poly sheeting, using more efficient IR film on some. Double poly sheeting creates an air gap and helps to prevent heat loss. Northwoods has also replaced single end walls in their greenhouses with double or triple end walls. "We found a double end wall product with a higher R-value and lower U-value than the triple wall poly, plus it was cheaper," says O'Leary.

Northwoods isn't sure yet how much energy these measures will save, because the same large propane tank feeds greenhouses with better insulation and without, making tracking propane savings difficult. However, O'Leary says the nursery will be able to quantify cost savings after a side-by-side trial in 2011 comparing energy use in a greenhouse with double wall poly covering the house against energy use in a single poly greenhouse. The nursery expects a fairly quick payback for their investment through a combination of a state tax credit and propane cost savings. They received a 35 percent tax credit through the state Business Energy Tax Credit program, which they sold to a third party as a pass-through tax credit.

The good news is that Northwoods has already heard anecdotal evidence that they're saving energy and propane costs from the greenhouse insulation – their propane supplier recently complained that their tanks didn't need nearly as much fuel to top off the tanks this trip as in the past. That's the kind of complaint we'd like to hear more often.

5. Reuse and Recycling of All Wastes

Description

While creating some waste through normal business operations is often unavoidable, nurseries will capture savings by following the longstanding environmental mantra: reduce, reuse, recycle. Nurseries that rethink how they do business and decrease the amount of solid and liquid waste - whether it is soil, plastic pots, or water - leaving the facility will decrease overhead costs in the process.

- Reduce. The less you purchase, the less you ultimately have to throw away. This is a critical first stage to waste reduction that often gets overshadowed by the later steps. While the purchase of some items is a requirement for operational continuity, nurseries can achieve savings by looking for ways to decrease their need for those items that end up in the waste stream. Consider all waste streams and ask yourself: Do we need this product or resource to do good business? Is it possible to rethink the way we do our jobs that will allow us to purchase less and save resources? Can you request decreased packaging on any purchased products?
- Reuse. There are many opportunities to reuse products and resources. Provided that a cleaning system can be instituted, soil and containers can both be reused at a very high rate. By reusing as many purchased products as possible, you will reduce your operational costs while limiting the indirect emissions being created during the products' manufacture, and in the waste stream.
- Recycle. For those products that can only be used once, or whose useful life is over, recycle or compost as much as you can. Plant clippings can be either taken offsite by haulers and composted with yard debris, or can be composted onsite to be used to fertilize plants if sterilized. Standard recyclables (cardboard, metal and most plastics) can be hauled offsite and recycled. Likewise, containers and other non-standard plastics can be recycled through Agriplas, a company that specifically caters to nurseries; in many regions, they will come directly to your nursery to pick up containers and other plastics and haul them away to recycle.
    - For a list of Agri-plas accepted materials and standards for cleaning before recycling, please visit http://www.agriplasinc.com/
    - For more information about composting, please visit www.climatefriendlynurseries.org/resources

Recommended Measure

Install an Onsite Container Cleaning Center

An on-site cleaning center allows for the reuse for the majority of nursery containers in such a way that simultaneously reduces labor costs. While the upfront capital investment required can be challenging (in the following case study of Heritage Seedlings this included the purchase of a steamer, site foundation, and a used refrigerated truck), the payback can be relatively quick (~1 year) depending upon your baseline consumption and turnover of containers. The combination of reduced cost for new containers, reduced container waste disposal fees, and reduced labor costs associated with weeding is a cost-effective sustainability trifecta.

Additional Benefits and Considerations: Weeds and Pathogens

The implementation of a cleaning system reduces the overall number of weeds to contend with, and allows employees to spend their time with other tasks. Please see the following Heritage Seedlings case study for multiple insights into the additional benefits of implementing this type of system.

In order to prevent the spread of *Phytophthora spp*., it is critical to ensure proper cleaning of plastic pots and containers. Before re-use or re-cycling, all such containers should be thoroughly cleaned at proper temperatures for the correct time. To sanitize pots, soak in >180 F water for at least 30 minutes or treat with aerated steam at 140 F for 30 minutes. (Treatment at 165 F for 30 minutes will eradicate most weed seed as well.)

Recommended Tools

Oregon Department of Agriculture, The Grower Assisted Inspection Program (GAIP) oregon.gov/ODA/PLANT/NURSERY/gaip.shtml#Additional_Information

Washington Oregon Recycling Council, 2009. Best Management Practices: guidelines for pathogen control at organic material processing facilities www.compostwashington.org.

Additional recommendations can be found at www.climatefriendlynurseries.org.

Potential Savings

Plastic Container Steam Treatment Cleaning System		
	40-acre Nursery	**400-acre Nursery**
Cost of Business as Usual (purchasing containers and disposal fees)	$1,500	$4,000
Implementation Cost	$6,000	$8,000
Payback*	~4 years	~2 years

* Opportunities for waste reduction improvements are site specific and vary.

Next Steps: Waste Reuse and Recycling

- Recycle all unusable pots and worn polyfilm from greenhouse covers.
- Before investing in a sterilization system for the reuse of containers, begin by documenting all monthly expenses related to the purchase and disposal of containers. This will enable you to realistically estimate savings and measure payback prior to implementation.
- Consider installing an onsite container cleaning center or renting a mobile system.

Heritage Seedlings, Inc. Saves Money and Labor by Steam Treating Containers and Soil

(Top) Heritage Seedlings, Inc. Stayton, Oregon facility

(Bottom) Weed-free propagation trays fill the greenhouses

By Whitney Rideout, Oregon Association of Nurseries (2010)

No one likes weeding. It's a back killer - and for nursery owners it's a huge outlay of time and money.

Heritage Seedlings, Inc. (Heritage) took progressive steps to nip weeds in the proverbial bud by steam cleaning and reusing both plastic containers and soil. In so doing, they reduced their carbon footprint and saved money from two elements of COGS (cost of goods sold): production materials and general labor. This is their story.

Heritage is a wholesale propagator of unique deciduous woody plants and Willamette Valley natives and perennials. Located in both Salem and Stayton Oregon, Heritage operates seven acres of greenhouses, 15 acres of cold frames, and 240 acres of field-grown liner production.

Heritage has reused its containers for years, but their decision to begin steam treating containers and planting media came from their participation in the Oregon Department of Agriculture 'GAIP' program (Grower Assisted Inspection Program). "Weeding takes a tremendous amount of resources that could otherwise be used to propagate or fill orders" said Heritage Manager Eric Hammond. "We were able to deal with the critical control points surrounding disease and container re-use, but we couldn't justify the huge labor bill for weeding. I clearly remember the 'profit-driven' pressure to produce clean liners crashing into the 'real-world' fact that we had rings of weed seedlings around the container sides before the tree seedlings had emerged. It was just... an impossible situation. Ethically we felt really good about our decision to re-use our containers in a 'reduce, recycle, re-use' sense, but in doing that - we compounded the weed problem year after year. We needed a solution that could help us maintain our high level of product quality, save a realistic amount of money, and continue to stay comfortable from a 'We're doing the right thing here' standpoint - in other words - sustainability."

The solution Heritage implemented was to hot water bath their small thin-walled plastic containers and steam treat their large thick-walled plastic containers and re-cycled potting soil.

(Top) Small thin-walled trays are cleaned in this cooker for ten minutes at 170 degrees

(Bottom) Refrigerated truck with attached steamer used to clean large thick-walled plastic baskets and bulb crates

Container Cleaning

Heritage Seedlings created two different stations to clean their plastic containers; one for small thin-walled containers and one for large thick-walled containers. The small thin-walled containers are treated in a hot water bath cooker that owner Mark Krautman bought at auction. The cooker takes a full day to heat up as its capacity is 1,000 gallons, but once it's heated it can clean a half-pallet of trays at a time. "10 minutes at 170 degrees - it works like a dream," said Hammond with a grin like a kid eyeing an ice-cream cone. "We run the cooker for only about a week to clean everything and then we shut it down and give it a rest until we have the need for fresh trays - it's a wonderful solution to a very difficult problem and it's relatively efficient from a labor perspective. While the cooker cleans the trays, employees can tend to other tasks. The trays technically need five minutes at that temperature for killing weed seeds, but we give the trays extra time to ensure they are clean and to give employees enough time to complete other tasks."

The cooker is ideal for the small trays, but Heritage found it too labor intensive for thick walled plastic baskets and bulb crates.

[Hammond] "We converted an old refrigerated truck into a steamer to handle the large baskets - same principle as the tray cooker - just bigger. The capital outlay was about $8,500 for the steamer, cement foundation and used refrigerated truck. The return on investment for the big steamer was less than one year; weeding labor is an enormous outlay so it doesn't take long to pay for something that helps you reduce it. Also, weeding isn't exactly the most rewarding work and so our employees spend more time doing the things they enjoy and taking pride in seeing the trees they planted come up. Bottom line, we're spending more time growing the plants we want to grow and less time battling the plants [weeds] we don't want to grow, so it's just all-around good for Heritage and its people."

Soil Cleaning

[Hammond] "We'd been generating a mountain of used potting soil that we wanted to re-use. But we knew there was a horrible weed seed-bank in it. When we enrolled in the GAIP with ODA, we were required to clean the soil to reuse it, and it was like - Well OK, in for a penny, in for a pound - let's figure out how to get this done. So we did, and again, the results have been very positive for us."

Soil cleaning steam system: trailer and steam generator system

Heritage runs steam through pipes at the bottom of a large trailer (see side pictures). The return on this investment was a mere five months:

- The variable cost [fuel + labor] to steam the soil: $15/cubic yard
- Delivered cost of new soil mix: $43/yard.
- Capital outlay for the steam generator and materials: $20,000.
- After only 700 yards of soil use the capital outlay was redeemed and now Heritage saves approximately $28/cubic yard for re-used clean soil

Results Go Beyond Time and Money

When asked if employee buy-in was difficult Hammond responded: "Not at all. Employee buy-in for all three activities was very quick. This solution has a very high: 'Hey we're doing the right thing here' common-sense appeal, and at the same time it allows people to spend more hours of their day doing more rewarding work. So, we saw a very quick return on investment, but more importantly, we are all more satisfied that we're not contributing to waste and pollution, and that we have more time to spend on valuable tasks like transplanting and staking."

The systems used at Heritage didn't happen overnight and there were both trials and errors in fine-tuning their cleaning solution to meet their needs. They recommend not getting hung-up on copying them or anyone else exactly, but rather focusing on the desired end-result and working backward and forward through the operations flow to identify the sources of problems before attempting to solve them.

[Hammond] "Once you really understand the root of your problems and where they impact your people and your costs, you'll be headed down the right path. Recycled container and soil steam treatment have been a big win for us - clearly - but more than that, they've led us to think more progressively about what else we might need to change. It clearly demonstrated to our crews the positive effect of solving the problem at the beginning. Our team is incredible and I'm very proud of them. At this point, I don't think there's anything we couldn't do if we put our minds to it."

6. Nutrient Use Efficiency

Research and analysis continues on the quantification of greenhouse gas (GHG) emission reductions that are possible from good soil management practices, including efficient plant nutrition and building soil organic matter. Agricultural use of nitrogen fertilizer is one of the most significant contributors to agricultural GHG emissions, and the manufacture of commercial fertilizer is a meaningful source of global GHG emissions. Likewise, agricultural soil management, which releases carbon dioxide (C02) and nitrous oxide (N20), constitutes 67 percent of U.S. agricultural GHG emissions.

While it is known that providing plant nutrition more efficiently and building soil organic matter will reduce GHG emissions, the Northwest does not currently have the research to quantify on-farm N2O emissions from fertilizer use, or the possible GHG reductions from more efficient provision of plant nutrition. However, the general benefits of nutrient use efficiency in terms of reducing costs, GHG emissions and protecting water quality are well established.

Field Nutrient Use Efficiency

Field nutrient use efficiency is the practice of accurately supplying the amount of nutrients required by a plant. Efficient nutrient application results in less fertilizer applied and less fertilizer waste.

Oregon State University researchers and extension agents have just begun to investigate nutrient removal, fertilizer timing, and subsequent crop response. Recent publications from OSU supporting this BMP are available on our website and additional recommendations herein are based on other relevant production guides and current practices of nurseries within the Willamette Valley.

To accurately manage crop fertility one must know soil type and texture, pH, cation exchange capacity, organic matter, and extractable nutrient content. Site-specific soil physiochemical properties are now available online via the Web Soil Survey (WSS, at websoilsurvey.nrcs.usda.gov). In addition, soil needs to be tested regularly to ensure adequate soil fertility and pH with the exception of nitrogen, sulfur and many of the micronutrients.

Nitrogen (N) applications should be applied in split applications via band, side-dress or fertigation to the area of the expected root zone during times of growth when nutrient uptake occurs readily. Nitrogen application rate should be reduced proportionally from an acre basis to a smaller application area when banding, side dressing, or fertigating. Growers can make inferences regarding the efficiency of current nitrogen fertilizer practices by conducting additional nitrogen soil tests during the year and adapting management to the results. Testing in April – June can indicate the need for additional mid-season fertilizer application, whereas August – September testing can help to determine if the total N supply from combined sources (irrigation water, soil and fertilizer) was excessive. The soil and your production system remain dynamic over time and may require adjustment to ensure optimal fertilization.

Phosphorus (P) moves very little in the soil profile; therefore, conventional fertilizers such as superphosphates, ammonium phosphates, or potassium phosphates are commonly top-dressed and incorporated between cropping cycles. If a phosphorus deficiency does occur during production, or one liquid fertilizes then drip irrigation can be used to apply phosphorus to the root area zone at the time of active root growth.

Bray phosphorus soil test method for acidic or neutral soils phosphorus is used to determine the need and quantity of phosphorus between cropping cycles as follows:

Bray P Soil Levels	Apply?	Amount of P_2O_5/A to Apply
0-20 ppm	Yes	100-125 lbs
20-35 ppm	Maybe	60-100 lbs
35+ ppm	No	None

Traditionally, potassium (K) is top-dressed and incorporated as potassium salts between cropping soils since soil potassium does not decrease rapidly during a perennial cropping cycle. Similar to nitrogen, potassium can also be applied very effectively via drip irrigation at times of active root growth. A potassium soil test is used to determine the need and quantity of potassium between cropping cycles as follows:

K Soil Levels	Apply?	Amount of K_2O/A to Apply
0-100 ppm	Yes	150 lbs
100-200 ppm	Maybe	0-150 lbs
200+ ppm	No	None

A more robust examination of nursery field nutrient use efficiency, including calcium, magnesium, sulfur and micronutrients is available at www.climatefriendlynurseries.org.

Container Nutrient Use Efficiency

As in field nutrient use efficiency, understanding the relationship between container media and nutrient application is essential to managing container nutrient use.

Pour Through Extraction to Test Efficiency

Application rates should be monitored and calibrated using the Pour Through Extraction method, which is a low cost, simple, in-situ method to extract the substrate solution from ornamental containerized crops grown in soilless substrates. By adding the minimal amount of water to displace the substrate moisture, a sample of this solution can be measured for pH and electrical conductivity (EC) to determine the efficiency of a fertility program. Samples may also be sent to off-site laboratories for a more detailed nutrient analysis to identify specific nutrient deficiencies or toxicities. Complete details for use of this method are included on the Climate Friendly Nurseries website in "Monitoring soilless substrate solution pH and soluble salts in containerized ornamental nursery crops" (Owens, Atland, Lebude & Stoven 2011).

pH:

Substrate pH for the majority of container plants should be approximately pH 5.5 (lower for ericaceous or other acid-loving plants). If pH rises above the target level for a given crop being monitored, corrective action should be taken, an on-site critical analysis should be conducted and cultural practices adjusted to take corrective action for future plantings.

EC:

Electrical conductivity (EC) is optimal for growth between 0.5 and 1.5 dS/m. This measure reflects the soluble salts being contributed by fertilizer which can leach from the container or are absorbed by the plant throughout the production process. In this way, EC can stand-in as a surrogate for the amount of fertilizer that remains in containers. Low salt levels indicate little available mineral nutrients, while high soluble salt concentrations indicate sufficient or excessively high nutrient levels. For more details on interpreting EC results, please refer to

"Monitoring soilless substrate solution pH and soluble salts in containerized ornamental nursery crops" (Owens, Atland, Lebude & Stoven 2011).

Pour-through data cannot be used as the sole indicator of current and future containerized crop health. Growers have to consider pH and EC in conjunction with cultural practices, pest management, chemical and fertilizer application records and visual signs of plant vigor.

Brief Description of Method:

Approximately one hour after normal irrigation of containers to saturation, place randomly selected containers on a catch-tray using a ring beneath the pot as a spacer to allow adequate room for drainage. Slowly pour the appropriate amount of on-site water (see complete directions for more details) over the surface in circles between the center and the wall of the container. Allow 15 minutes for the water to leach through the pot, then remove the container from the tray and collect the leachate sample. Using a calibrated pH/EC meter, measure and record the substrate solution extract. For large containers, this method can be altered by lifting and tipping the container approximately 45 degrees just 45 minutes after irrigation, resulting in drainage of a more even sample. Please refer to complete instructions for sampling and interpretation in "Monitoring soilless substrate solution pH and soluble salts in containerized ornamental nursery crops" (Owens, Atland, Lebude & Stoven 2011).

Suggested Limits:

Suggested limits and ranges for chemical capacity factors and individual nutrients for irrigation water, mid-season substrate leachate of woody ornamental nursery container crops.

Table 3 from "Monitoring soilless substrate solution pH and soluble salts in containerized ornamental nursery crops" (Owens, Atland, Lebude & Stoven 2011).

Capacity Factor	Irrigation Water	Leachates (BMP's & VTEM [Y])
pH	5.4-7.0	5.2-6.3
Conductivity (mS/cm)	0.2-2.0	0.5-2.0
Total Dissolved Salts	<1000 ppm	<1400 ppm
Bicarbonate	<122 ppm or <2 meq/L	---
Alkalinity (carbonate + bicarbonate) [1 meq/L = 50 ppm $CaCO_3$]	<100 ppm $CaCO_3$ or <2 meq/L	---
Sodium Absorption Ratio (SAR)	<10 meq/L	---
	Individual elements	
Nitrogen (N)	---	100-150 ppm
Nitrate-N (NO_3-N)	10 ppm	50 ppm
Ammonium-N (NH_4-N)	2-10 ppm	50 ppm
Phosphorus (P)	<1 ppm	3-15 ppm
Potassium (K)	<10 ppm	<100 ppm
Calcium (Ca)	<60 ppm	40-200 ppm
Magnesium (Mg)	<6-24 ppm	10-50 ppm
Sulfur (S)	<24 ppm	75-125 ppm
Iron (Fe)	0.2-0.4 ppm	0.3-3 ppm
Manganese (Mn)	<0.5-2 ppm	0.02-3 ppm
Zinc (Zn)	<0.3 ppm	0.3-3 ppm
Copper (Cu)	<0.2 ppm	0.01-0.5 ppm
Boron (B)	<0.5 ppm	0.5-3 ppm
Molybdenum (Mo)	<0.1 ppm	0-1 ppm
Aluminum (Al)	0.05-0.5 ppm	0-3 ppm
Fluoride (Fl)	<1 ppm	---
Sodium (Na)	<3 meq/L or <50 ppm	<50 ppm
Chloride (Cl)	<70 ppm	<70 ppm

z Values for foliar nutrient levels are most applicable for woody broadleaf evergreen nursery crops.YBMP stands for "best management practice" and VTEM stands for "Virginia Tech Extraction Method"

Bailey Nurseries Balances the Nutrient Budget in a Climate Friendly Manner

By: Jennifer Marie Nelson, JD MS (2011)

Whether the scale is small or large, a budget requires keeping a sharp eye on both what you put out and what you bring in. Bailey Nurseries' Newberg Farm works to keep both the budget and the environment in the black. The high cost of fertilizer drives a partnership between smart business sense and an ethic of land stewardship at Bailey with astounding results. Ross Dumdi, the West Coast Plant Health Department Head for Bailey, puts the value of nutrient management in cold, hard numbers everyone can all appreciate."By putting a large focus on our nutrients, we have been able to save over 50 percent of our fertility costs."

Bailey Nursery Newberg, Oregon

Bailey achieves these savings through careful nutrient budgeting. Much like checking the balance in a savings account before making a major purchase, Dumdi begins by analyzing nutrients available in the soil before applying additional supplies. Utilizing GPS and monitoring systems as well as annual soil testing for each field over a wide array of macro and micro nutrients, Dumdi is able to address the needs of individual fields through their fertility program. "We're starting to pick up the concept of fall soil testing. We're trying to utilize soil samples before the rainy season, before the nutrients have the opportunity to get leached out, so that we can see what available nitrogen is still left in the field. Then we can adjust our spring and summer nutrient program accordingly."

The nursery further customizes its nutrient budgeting by carefully managing their nutrient investments through use of multiple check rows and banding equipment for application rather than broadcasting. "Here at the nursery, we use check rows - that's the only way you can truly evaluate your current program," says Dumdi. The use of check rows allows an accounting of sorts by letting Bailey nurseries accurately measure the effect of their fertility program, rather than simply relying on assumptions. This in turn allows Dumdi and his team to fine tune application rates, adding up to significant reductions in both nutrient additions and costs. "If you don't have a control, you have no way of measurement. It's really helped us rethink our processes by allowing us to ask ourselves, 'is that expense really worthwhile?'"

As a result, Bailey has re-thought the needed nitrogen application rate for their cover crop, nursery and carry-over material, which in turn has allowed them to fine tune their application methods even further. "Instead of utilizing a helicopter or a broadcast spreader, we started to become more precise through banding, allowing us to apply the nutrients very close to the roots of the plants," reports Dumdi. "You're just putting the nutrients where

they belong, so you get better utilization by the plant as well and less leaching."

Careful nutrient budgeting at Bailey isn't limited to field operations. Isaak Stapleton has seen dramatic changes in fertilizer and irrigation efficiency while managing plant health for container operations during the last five years as a result of a combined strategy of careful monitoring and utilization of potting mix custom blended on-site. As costs for fertilizer inputs and irrigation were on the rise, Bailey began to consider switching from commercially available pre-mixes to a house-blended mix and reducing the rates. "Part of it was the cost because it was quite expensive. The commercial pre-mixes were a catch-all blend from the manufacturer: nitrogen, all your lime package, some of your micronutrients. In 2010, we took a look at that and realized we were spending money on ingredients we didn't need in our premix and could also reduce our rate by around half." The nursery decided that it could save money on inputs as well as reduce issues with salts by stripping down the mix to the bare essentials and cutting application rates. According to Stapleton, "We already have minors in our Controlled Release Fertilizer (CRF) we incorporate at planting, so we don't need that. We just broke it down to its raw elements and that's it." Bailey began testing its own blends in potted trials and made the switch when it resulted in improved plant health and reduced need for irrigation while still maintaining their target pH.

These changes have been very effective in reducing costs associated with the nutrient budget and the nursery plants aren't hurting from the reduced nutrient load either – in fact, there has been some improvement in root health. "We aren't seeing as much root tip burn on some of the green plantings that we do because the salts aren't as high and we've leached less, so there is less root burn and less fertilizer wasted."

Simple technological improvements in fertilizer application have reduced costs and inputs as well. The nursery now uses Green Elf fertilizer applicators, which provide a consistent pre-measured application of CRF as a top dressing, thereby improving the accuracy and consistency of application, reducing labor inputs and allowing for more precise fertilizer orders. Stapleton believes that the practice is "super efficient as far as the grams you are putting in the pot because its very consistent. Instead of using the spoon to scoop and dump fertilizer down a funnel into the top of the pot, you get the same application with each pull of the trigger. There's less labor and less wasted fertilizer use." The time savings are incredible too: "We had three guys top dress the entire nursery in about 4 weeks," using this technology says Stapleton. "Considering weather related delays, that was very efficient, applying 65,000 pounds of fertilizer to somewhere between 75 and 100 acres of pots." The consistency of the application rate has reduced ordering error as well and thus helped to save on storage related costs between growing seasons. In general, efficiency measures like these help to reign in operating costs and environmental impacts: "The more you can improve efficiency, the better."

On the container side of the nursery, nutrients and irrigation are always linked. Although irrigation may be necessary to control salts and cool foliage when plants are initially planted, it can increase fertilizer costs if nutrients are leached in the process. Bailey uses pour-throughs as a way to track fertilizer release and to illustrate to the irrigators the effect of watering. In new plantings, pour-throughs have helped to identify the optimal rate of irrigation for both salts and cooling while preventing unnecessary leaching, resulting in reduced nutrient inputs as well as savings on irrigation costs. Throughout the nursery, nutrients and water are both conserved through irrigation re-capture and re-cycling, providing a nutrient bonus virtually free of cost.

Back in the field, the investment in soil fertility is further protected by the use every 3 to 4 years of a cover crop of corn, 100 percent re-incorporated into the soil in order to passively recapture all of the nutrients utilized to grow the corn. This practice results in nutrients released more slowly over the next 3-4 year cycle of nursery crops, further increasing cost savings and extending the life span of soil fertility. Use of a dwarf barley in the fall and winter cover crop (which dies back in winter without use of herbicide control) increases organic matter when tilled in during the spring as well as helping to reduce weeds and soil compaction.

Dumdi embraces Bailey Nursery's adaptive management: "I'm a firm believer in evaluating what you do and why you do it. We've really changed throughout the last five years, challenging what the old standards were. The driving factor was cost." The return on this investment of time and the risk of taking on a new strategy has improved the bottom line in production as well, with fertility doubling or tripling during that time. In the end, the spreadsheet for this budget is pretty simple: "If I can produce the same size and quality plant with reduced fertilizers and reduced costs, Bailey Nurseries is making more money." For Bailey Nurseries, however, nutrient conservation isn't merely a matter of economics. While acknowledging fertilizer "isn't cheap," Dumdi also embraces the nursery's commitment to climate friendly practices. "We're stewards of the land. We have to be conscious of what we are doing to our soils. We live off of our soils as well as make our money off of them."

7. Vehicle Fuel Efficiency

As concerns about fuel costs and climate impacts rise, there are simple strategies for increasing vehicle fuel efficiency in the field and throughout a nursery operation that can reduce your carbon footprint and improve your bottom line.

Recommended Measures:

Improve Fuel Storage Facilities

Reduce losses from fuel storage tanks by up to 90 percent through the following measures:

- Reduce Temperature: Locate fuel tanks in a shady area to reduce evaporation. Paint fuel tanks light colors or use aluminum tanks to keep temperatures down and reduce evaporation.
- Reduce Fuel Losses: Replace conventional gas caps with pressure-relief vacuum caps to reduce fuel losses. Lock unattended fuel tanks.
- Check for Leaks: Regularly inspect tanks for leaks, tightening connections at the tank outlet and pump. Check for seepage at valve packing and nozzles. Carefully inspect underground storage tanks for leaks that threaten water quality.

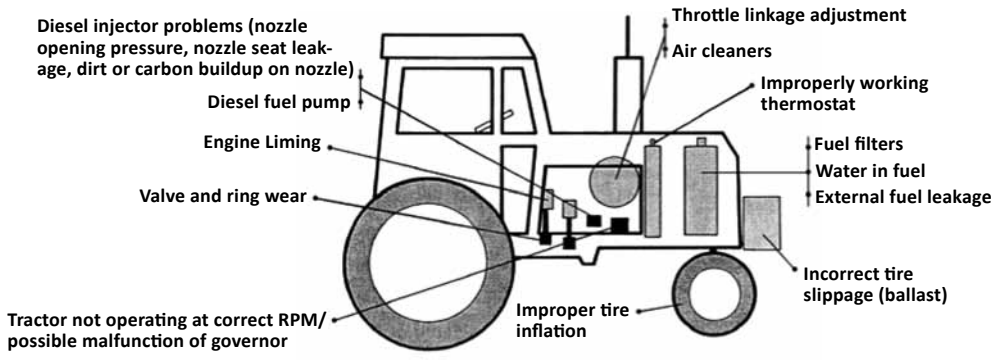
Vehicle Investment Considerations

Selecting nursery equipment is often the first step in reducing fuel consumption and greenhouse gas emissions. This long-term investment could impact the financials of your operations for years to come as well. The following considerations could help improve your vehicle performance and save cost:

- Purchase Fuel Efficient Equipment at Start-Up: Although EPA does not currently test farm equipment to meet vehicle fuel efficiency standards, other standards programs exist and can be consulted. For example, you may look for vehicles which comply with the ISO 14001 Environmental Standards set by the United Nations Environment Program.
- Switch to Electric: For nursery operations in a confined area, switching to electric vehicles wherever possible can reduce fluctuation in fuel costs associated with gasoline and diesel. Electricity in the Pacific Northwest often provides a cleaner, more local fuel source as well.
- Upgrade to more fuel-efficient models: When it's time to replace your equipment, compare fuel requirements of different makes and models. A higher purchase price can be partially offset by lower fuel costs. The Nebraska Tractor Test Laboratory conducts performance tests of tractors, including fuel performance. Test reports for many tractor makes and modes are available online at http://tractortestlab.unl.edu.

- Diversify Fuel Options: Consider investing in equipment that can run on alternative fuels such as bio-diesel or propane. Use fuels that meet the American Society for Testing Materials (ASTM) standards for fuel quality to ensure good engine performance. If using biodiesels, initially watch for potential clogs to fuel injectors as sediments are flushed from the tank. Upfront costs can include significant investment in refueling infrastructure and may require careful consideration.

Factors Reducing Fuel Efficiency in a Diesel Tractor



Vehicle Maintenance

Proper vehicle maintenance improves climate friendliness not only by increasing fuel efficiency but also by preserving vehicle life and reducing waste associated with replacing equipment. Be sure to:

- Tires: Regularly check tire pressure (especially when weather is cold) and align/balance tires to ensure maximum fuel efficiency for all fleet vehicles and extend tire life. Just one tire underinflated by six pounds per square inch (psi) can increase fuel consumption by three percent.
- Engine Maintenance: Conduct routine maintenance at regularly scheduled intervals as recommended by manufacturer. One fouled spark plug or one stuck valve lifter can increase fuel use by 10 to 15 percent. Blocked air filters can increase fuel consumption by as much as 20 percent.
- Oil Changes: Change the oil and replace air/oil/fuel filters on all feet vehicles at regular intervals. Regularly scheduled tune-ups can save 10 percent on fuel usage. Use the proper grade of oil to extend engine life, reduce excess costs associated with oil changes and reduce number of oil changes needed throughout the year.
- Thermostats: Make sure your thermostat works properly. A properly working thermostat saves energy. Most engines run most efficiently when water temperature is between 165 and 180 degrees F. Fuel consumption increases by approximately 25 percent when the engine is operating at 100 degrees F, instead of 180 degrees F. Check your owner's manual for more information.

Vehicle Operation

How a vehicle is operated adds up to a substantial climate impact over time – implement the following best practices to save fuel and reduce emissions throughout the work day:

- Right Tool for the Job: Select the smallest practicable vehicle for the task – the smaller the engine, the greater the fuel efficiency.
- Reduce Idling: Implement a "no-idle" policy during loading/unloading operations to reduce engine run time, save fuel and reduce greenhouse gas emissions. Idling can consume 15 to 20 percent of the fuel used. Letting an engine idle for 10 minutes during an average day, or 61 hours a year, will use about 31 gallons of fuel on a 75-horsepower diesel tractor. When idling is required for non-movement related operations, switching to electric vehicles or alternative fuels can reduce fuel costs and emissions while protecting health of workers.
- Reduce On-Site Miles: Arrange nursery operations to reduce on-site miles traveled by vehicles throughout the day.
- Gear up and throttle down when you are not hauling weight: For applications requiring less than 65-70 percent of full engine power, it is best to slow down the engine rpm and shift to a higher gear to maintain engine speed. This will reduce the amount of fuel used.
- Operate Equipment with Care: Avoid quick starts—they waste fuel and are hard on equipment. Run equipment in the proper gear for the load. Reduce excess vehicle weight to increase fuel efficiency. Try to operate vehicles at an even pace to improve fuel efficiency rather than rapidly accelerating and breaking frequently.
- Fuel: Use the recommended grade of fuel to reduce unnecessary cost – check your owner's manual for specifics. Consider re-using oil as equipment fuel where appropriate – it is possible to recycle well-filtered oil for use in diesel equipment. Be sure to check with the engine manufacturer before burning waste oil in engines under warranty. Soybean or cotton seed oil blends with diesel fuel may also be economical alternatives.

Field Operations

Managing field operations can also reduce costs and emissions associated with operation of equipment by reducing the amount of work that needs to be done. The following practices are suggested for field operations:

- Tires: Reduce tractor tire slippage to a maximum of 15 percent by utilizing the correct amount of ballast for the weight of your load. Increase ballast for light loads to prevent slippage. Reduce ballast for heavier loads to improve fuel efficiency. Utilize the right tire for your soil type. In soft, loose soils, duals will increase the contact area between the tire and soil, which can be more effective for increasing drawbar power than adding ballast.
- Continue Wise Operation Practices: Be sure to use the smallest available equipment appropriate for the task and to reduce on-site miles traveled through careful planning in the field just as you would elsewhere around the nursery. Incorporate efficient travel patterns to reduce on-site miles by minimizing turning and staying on a level path whenever possible. Operate field equipment at the recommended speed to maximize fuel efficiency.

Recommended Tools

Conserving Fuel on the Farm
https://attra.ncat.org/attra-pub/consfuelfarm.html

Energy Estimator: Tillage (USDA)
http://energytools.sc.egov.usda.gov

National Biodiesel Board
http://www.biodiesel.org/

Energy Ideas Clearinghouse
http://www.energyideas.org/

Colorado State's Selecting a Fuel Efficient Tractor
http://www.ext.colostate.edu/pubs/farmmgt/05007.html

Potential Savings

When it comes to vehicle fleet improvements, calculating savings in dollars over time can be difficult because fuel prices are variable between fuels and fluctuate over time. The practices mentioned above can reduce fuel consumption by demonstrated percentages:

Practice	Percent Savings	Source
Improvements to Fuel Storage (combined)	Up to 90% reduction in fuel losses.	*Conserving Fuel on the Farm*, ATTRA
Vehicle Maintenance:		
Inspect and replace faulty spark plugs	Prevent loss of efficiency up to 15% / malfunctioning spark plug	*Conserving Fuel on the Farm*, ATTRA
Inspect and replace dirty air filters	Prevent loss of efficiency up to 20%	*Conserving Fuel on the Farm*, ATTRA
Regularly scheduled tune-ups	Save 10% on fuel usage	*Energy Conservation for Greenhouses & Field Nurseries*, U. Mass. Extension
Inspect and repair thermostat	Reduce fuel consumption up to 25% by running engine at proper temperature	*Conserving Fuel on the Farm*, ATTRA
Properly inflate tires	Avoid increased fuel consumption of 3% for each tire under-inflated by 6 psi. Use 20 percent less diesel fuel and improve productivity more than 5 percent by not overinflating tractor tire pressure.	*Conserving Fuel on the Farm*, ATTRA *Fuel Efficiency on the Farm*, California Farm Bureau Federation
Vehicle Operation:		
Prevent unnecessary idling	Reduce fuel consumption up to 20%	*Energy Conservation for Greenhouses & Field Nurseries*, U. Mass. Extension
Accelerate gradually and drive smoothly	20% increase in fuel economy	*Fuel Conservation Strategies for the Farm*, Alabama Cooperative Extension System
Use soybean / cottonseed oil blends with diesel	Cost savings based on low prices of vegetable oil (20 cents or less per pound)	*Energy Conservation for Greenhouses & Field Nurseries*, U. Mass. Extension
Field Operations:		
Employ conservation/no-till strategies	Savings up to $10/acre	*Conserving Fuel on the Farm*, ATTRA

Nobody Bats a 1,000, but We're Working to Improve Our Average

"Don't let the fear of striking out hold you back."

-Babe Ruth

By Whitney Rideout, Oregon Association of Nurseries (2011)

Babe Ruth was the greatest slugger in the history of major league baseball – his records have stood for generations – and yet he missed more than three of every 10 pitches that came his way. Brooks Tree Farm, Inc. (Brooks) threw us their best pitch. Truth be told, it went right by all the knowledge gathered to date through the Climate Friendly Nurseries Project (CFNP) into the mitt – even though the project swung as hard as it could. It's not a loss when you swing and miss if you learn something from it, and we most definitely did.

This case study outlines Brooks' 2011 efforts to identify ways to reduce greenhouse gas (GHG) emissions. It demonstrates Oregon nursery industry commitment toward sustainable practice implementation, and also reveals the complex labyrinth of programs and lack of information, which at times, serves as a barrier to implementation.

Brooks is a family owned nursery specializing in plants for the Christmas tree, timber, and ornamental nursery trades, as well as plants native to the Pacific Northwest used for habitat restoration. They provide bare root seedlings, transplants, plugs and grafting stock from two Willamette Valley, Ore. locations. Their full annual production of seedlings is 6-8 million trees with 4-6 million plants sold each year.

Kathy LeCompte, co-owner of Brooks and former Oregon Association of Nurseries president, has taken steps over the years to make her farm more sustainable. She has installed variable speed drives, efficient sprinklers and gaskets, and efficient greenhouses, but she wanted to implement another practice to assist the CFNP in its goal to identify practical ways to reduce GHG emissions.

Kathy investigated many options listed as Best Management Practices (BMPs) on the CFNP website (www.climatefriendlynurseries.org) including lighting upgrades, installing infrared polyethylene, and replacing condensing units in their cold storage rooms. [LeCompte] "Lighting retrofits didn't provide the ROI we needed since we don't use a lot of lighting. Infrared polyethylene would have forced us to use more energy in total because the crops we grow don't need a lot of additional winter heat but would have needed a lot of extra ventilation in the summers. And replacing the condensing units proved very expensive ($20,000 to $35,000 each), and the payback was not clear since the efficiency savings hasn't been proved consistently to date." While most BMPs did not pan out for Brooks, LeCompte identified a greenhouse

efficiency item with a reasonable payback period, an attractive incentive, and sufficient benefit to her operation to justify the cost and time of the project: old fans in their greenhouses were replaced with fans with proven energy efficiency benefits.

[LeCompte] “Information about incentives and rebates is fragmented, and a lot of the new efficient equipment hasn’t been evaluated for true cost savings. Small businesses with limited staff and peak season times don’t have the bandwidth to address the maze of information to identify practices that benefit their operation. As an industry, we need to create better tools and resources to help evaluate sustainable practices.”

Oregon nurseries are tremendously varied in terms of the product they grow and how their plants are produced, sold and shipped. Initial BMPs published in 2010 are not yet comprehensive enough to work for every type of nursery operation. On top of that, the complexity of resources and programs and the lack of equipment efficiency data make ROI analyses a challenge. As Babe Ruth said, “Don’t let the fear of striking out hold you back.” CFNP concludes in 2013, and the goal is to provide more tested, effective, and actionable best practices to the industry.

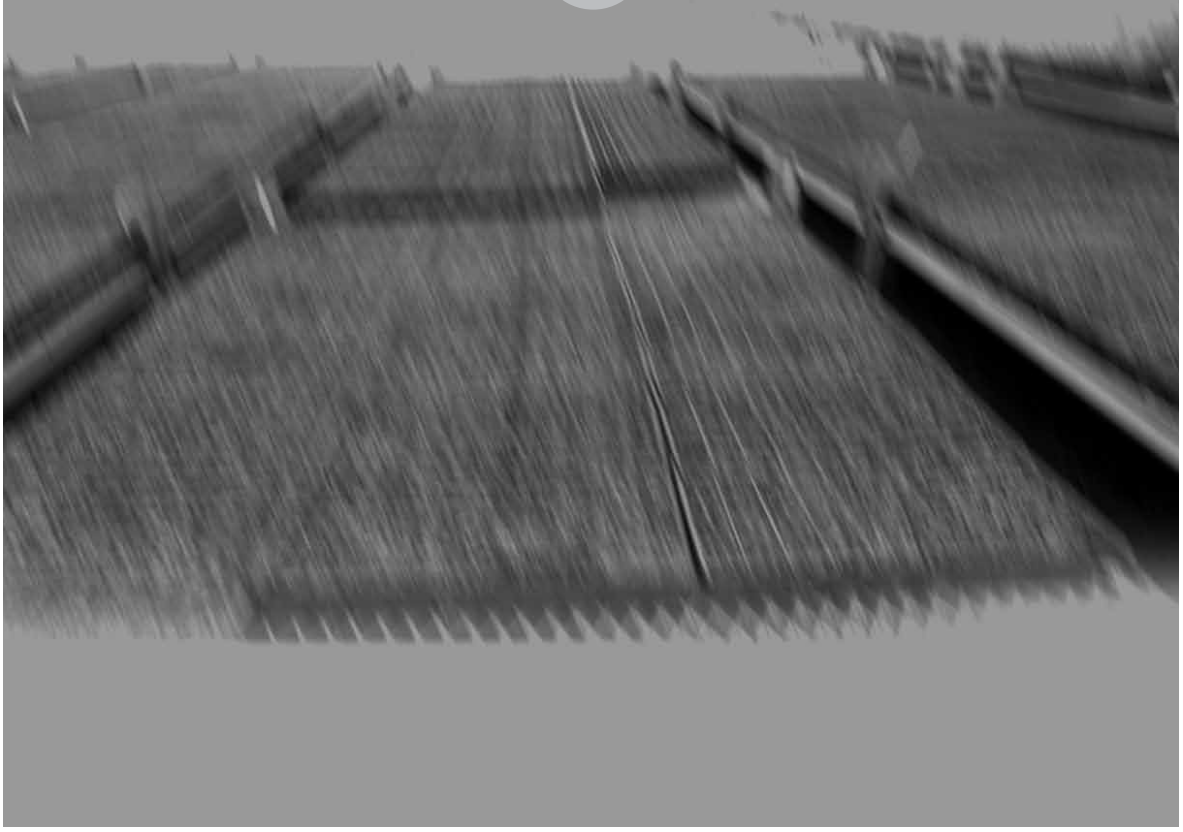
Low-Cost/ No-Cost Best Management Practices

Best Management Practices Requiring Up front Capital

Available Incentives

Guide Methodology

Next Steps



Low-Cost/No-Cost Best Management Practices

The following section lists a number of opportunities that require little or no capital to implement. For the most part, these measures do not require external expertise, and can be put into practice by nursery employees. Opportunities are rated based on the energy savings captured for the related upfront costs (energy efficiency return on investment, or EE ROI), the level of GHG emissions mitigation for the cost (GHG return on investment, or GHG ROI), and the relevance to nursery operations throughout the industry (applicability). Each category is rated as a "high," "medium," or "low" level of opportunity. For further explanation regarding the rating system used in this section, please see the "Guide Methodology" section of this report.

Incentives that apply to each measure are also noted, although many of these measures will be cost-effective opportunities without funding assistance, or they are changes in behavior which require no capital output. Where standard incentives are available, they are listed in the "Incentives" column. Information regarding the following incentive programs, as well as others, is included.

- Energy Trust of Oregon (ETO), www.energytrust.org
- Other public utilities use Bonneville Power Administration (BPA) trade allies http://northwestlighting.org
- Oregon Conservation Tax Credit (CTC), www.oregon.gov/ENERGY/CONS/BUS/BETC
- USDA's Renewable Energy for America Program (REAP), www.rurdev.usda.gov/or/reap.htm
- USDA's Environmental Quality Incentives Program (EQIP), www.nrcs.usda.gov/programs/eqip/

Additional information on these incentive programs is included in the "Available Incentives" section of this report.

Lighting Efficiency

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Switch out incandescent light bulbs for compact fluorescents (CFL)	High	High	High	REAP grants can cover up to 25% (max $250,000) of eligible project costs. See also REAP loan programs. ETO and CTC also offer incentives for this measure.
Install auto-lighting (e.g., timers, motions sensors)	High	High	Medium	ETO offers a number of standard incentives for lighting fixtures and controls. For custom projects and retrofits, ETO can cover up to 35% of approved project costs (not to exceed $0.17 per annual kWh). CTC and REAP also offer incentives for this measure.

Heating and Cooling Efficiency

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Install programmable thermostats (options range from basic models to more sophisticated varieties that offer functions like tracking the weather)	High	High	High	
Limit heat use to offices and buildings, or those parts of greenhouse that require controlled environments	High	High	Medium	ETO offers incentives ranging from $1.50-$6.50 kBtu/hr in for premium efficiency natural gas equipment (e.g., direct fired radiant heating, tankless hot water) as well as a standard incentive of $1,000 for boiler dampers.
Seal cracks/make environmental system airtight	High	High	Medium	
Complete maintenance/operational activities on an ongoing basis (e.g., keeping doors shut, cleaning fans, etc.); applies to cold storage and packing rooms as well as greenhouses	High	High	High	

Refrigeration Efficiency

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Maintain all systems on a normal basis (e.g., checking for seal health and coolant leaks)	Low	Medium	High	

Irrigation/Fertilizer Efficiency

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Don't over irrigate, as it leads to fertilizer leaching through container	Medium	High	High	
Pay attention to irrigation timing: (a) study the release curve of the fertilizer you are using and apply accordingly, and (b) analyze application timing requirements and apply only when plants need it	Low	High	High	
Pay attention to nutrient amount: (a) apply recommended rate or tested rate; (b) be familiar with starter package and what you are adding to the container, and (c) liquid feed only when micro-irrigating	Low	High	High	
Monitor herbicide rates and application techniques along with water use to reduce herbicide movement	Low	High	High	
At container nurseries, monitor electrical conductivity (EC) over time so that you know the release of the fertilizer being used and only apply it as needed	Low	High	High	
Maintain all irrigation equipment on a normal basis to ensure the best efficiency	Medium	High	High	

Project Planning

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Look into assistance provided by ETO and BPA: they offer technical advice and/or funding to help plan efficiency projects, and provide contacts for technicians and contractors	High	High	HIgh	ETO and EQIP (incentives vary)
Complete a measure feasibility study	Low	Low	High	REAP offers grants specifically for feasibility studies which nurseries are generally eligible for
Get free advice! Check for technical assistance available in the area. Encourage local governments and institutions to take advantage of REAP and other programs to develop community-based energy audits for agricultural producers and rural businesses	High	High	High	REAP offers up to 25% of costs for feasibility studies for qualified applicants (max $50,000).

Contact the Oregon State University Energy Efficiency Center for a low-cost energy audit.
eec.engr.oregonstate.edu/ag

Other Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Initiate educational and/or incentive programs for low-carbon commuting and business travel (air travel for business is often overlooked but has enormous GHG impacts)	Medium	High	Medium	CTC offers a tax credit worth up to 35% of program design and implementation.
Recycle used containers through Agri-plas	Low	High	High	
Recycle all general types of waste (paper, plastic, cardboard, glass, etc.)	Medium	Medium	High	

Best Management Practices Requiring Upfront Capital

The following section outlines a number of best management practices that have the potential to reduce operational resource consumption and GHG emissions. Different from those listed in the previous section, the measures included here will require a higher level of upfront capital to be implemented.

Opportunities are rated based on the energy savings captured for the related upfront costs (energy efficiency return on investment, for EE ROI), the level of GHG emissions mitigation for the cost (GHG return on investment, or GHG ROI), and the relevance to nursery operations throughout the industry (Applicability). Each category is rated as a "high," "medium," or "low" level of opportunity. For further explanation regarding the rating system used in this section, please see the "Guide Methodology" section of this report.

Incentives that apply to each opportunity are also noted in the "Incentives" column. Information regarding the following incentive programs, as well as others, is included here.

- Energy Trust of Oregon (ETO), www.energytrust.org
- Other public utilities use Bonneville Power Administration (BPA) trade allies http://northwestlighting.org
- Oregon Conservation Tax Credit (CTC), www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml
- USDA's Renewable Energy for America Program (REAP), www.rurdev.usda.gov/or/reap.htm
- USDA's Environmental Quality Incentives Program (EQIP), www.nrcs.usda.gov/programs/eqip/

Additional information on these incentive programs is included in the "Available Incentives" section of this report.

Lighting Efficiency

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Install skylights in offices, warehouses, and propagation houses	Medium	Medium	Medium	CTC offers a tax credit worth up to 35% of design, materials, and installation.

Heating and Cooling Efficiency

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Upgrade greenhouse cover	High	High	Medium	CTC offers a tax credit worth up to 35% of design, materials, and installation (50% for combined heat and power). ETO and REAP also offer incentives for this measure.
Add diffuser cones to ventilation fans that funnel the air, allowing the motor to work more efficiently	Medium	Medium	Medium	ETO, REAP and BETC offer incentives for this measure.
Convert to more efficient heating systems (condenser boiler systems, radiant heating)	High	High	Medium	REAP grants can cover up to 25% (max $250,000) of eligible project costs. See also REAP loan programs. Priority given to grant asks below $20,000. ETO and BETC also offer incentives for this measure.
Use more efficient fans and motors	High	High	Medium	ETO offers incentives ranging from $10-$2,000 for efficient electric motors, with additional incentives for premium efficiency motors. REAP and BETC also offer incentives for this measure.
Install energy curtains	Medium	Medium	Medium	ETO, REAP and BETC offer incentives for this measure.
Install a combined-heat-and-power system	Medium	Medium	Medium	ETO offers incentives of $120-$300 on efficient air-conditioning units. REAP and BETC also offer incentives for this measure.
Install Variable Speed Drives (VSDs) on cooling systems	High	High	High	ETO offers standard cash incentives of $0.20/sq foot of efficient insulation. Custom incentives are also available. REAP and BETC also offer incentives for this measure.

Irrigation/Fertilizer Efficiency

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Install premium efficiency irrigation pumps	Medium	High	High	Check EQIP Agricultural Water Enhancement Program (RFPs to be announced) for opportunities. ETO, REAP, and CTC also offer incentives for this measure.
Install Variable Frequency Drives (VFDs) for irrigation pumps	Medium	High	High	EQIP Conservation Activity Plan can recuperate up to 75% of costs and loss of income due to program implementation (up to 90% for projects with special environmental significance). ETO offers up to 50% cash back for adding a VFD to a new or existing pump. REAP and CTC also offer incentives for this measure.
Monitor soil moisture, preferably in conjunction with an irrigation system upgrade. This will allow you to only pump and use water when it is needed.	Medium	High	High	ETO, EQIP, CTC and REAP all offer incentives for this measure.
Convert existing irrigation system to drip or linear/pivot system	Medium	High	High	ETO offers cash incentives ranging from $1-$3 per part for linear and pivot irrigation system improvements, and from $0.25-$8 for wheel and hand-line improvements. EQUIP, CTC and REAP also offer incentives for this measure.
Use Controlled-Release Fertilizer (CRF), as it is less likely to run off. If liquid feed is being used, amplify it via micro-irrigation rather than using an overhead irrigation system. If an overhead system is being used, be vigilant about runoff.	Low	High	High	
Do not broadcast CRF	Low	High	High	

Refrigeration Efficiency

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Upgrade to systems that require less GHG-intensive refrigerants (e.g., ammonia systems)	Low	Medium	Medium	

Water/Wastewater Efficiency

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Manage water drainage system	Low	Low	High	
Use rip rap, grass waterways or sediment traps to assist in managing onsite water	Low	Low	High	Check EQIP Agricultural Water Enhancement Program (RFPs to be announced) for opportunities.
Use constructed/floating wetlands and catch basins to clean water before it enters the containment pond	Low	Low	High	
Create a bed and nursery design to efficiently capture water for reuse	Low	Low	High	

Onsite Energy Production

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Install solar panels to create onsite energy	Medium	Medium	Medium	REAP grants can cover up to 25% (max $500,000) of eligible project costs. See also REAP loan programs. ETO offers $0.50-$1.25/watt produced through solar electric. For PGE customers, this is capped at $500,000-$600,000. For Pacific Power customers, this is capped at $100,000.
Install a solar hot water system to meet nursery heated water needs	Medium	Medium	Low	ETO offers incentives for up to 35% of the project cost (typically 10-15%) associated with commercial solar hot-water.
Install a hydroelectric or hydrokinetic system	Medium	Medium	Low	ETO offers to cover up to 50% of the costs (max $40,000) associated with project development assistance for large-scale wind, biopower, geothermal, and hydroelectric energy projects. They also offer funding to implement and install such projects. These funds are not capped, and are provided for a negotiated share of ongoing energy profits in the form of "green tags."
Install wind microturbines on site	Medium	Medium	Medium	ETO offers incentives of up to $60,000 for small-scale wind power projects.
Install geothermal heat pumps	Medium	Medium	Medium	
Install fuel cells	Low	Low	Medium	

Fleet/Transportation

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Be sure all transportation equipment is tuned on a normal basis	Medium	Medium	Medium	CTC offers a tax credit worth up to 35% of costs.
Reduce tillage trips over the field	Medium	Medium	High	
Purchase and use more fuel-efficient vehicles for trips that do not require heavy cargo capacity (e.g., electric vehicles like golf carts and plug-in cars, or bicycles)	Medium	Medium	Medium	
Use biofuels in existing vehicles where possible	Medium	Medium	Medium	

Other Measures

Measure Description	EE ROI	GHG ROI	Applicability	Incentives
Practice integrated pest management	Low	Medium	High	
Plant cover crops, inter-row crops or plant material in areas of high erosion risk. For bare root nurseries that harvest in the winter, straw mulch can be applied during or post-harvest to reduce the impact on cover crops	Low	Low	High	
Reduce reliance on plastics and materials that need to go to the landfill	Low	Medium	Medium	

Available Incentives

Incentive Database Websites

The following website offers good information regarding available incentives for best management practices:

- Database of State Incentives for Renewables & Efficiency (DSIRE) at www.dsireusa.org offers a searchable database for federal and state incentives.

There is also great information available at each program's website; many offer searchable databases for the type of project you are looking to fund.

- Energy Trust of Oregon (ETO) at www.energytrust.org offers incentives for commercial, agricultural and industrial customers of any one of the state's investor-owned utilities to increase the energy efficiency of their existing buildings.
- Oregon's Conservation Tax Credit (CTC) at www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml provides a tax credit worth up to 35 percent of costs for an energy efficient project.
- Oregon Small Renewable Energy Grant Program at www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml will provide grants to businesses for small-scale renewable energy projects.
- The federal Rural Energy for America Program (REAP) at www.rurdev.usda.gov/or/reap.htm offers grants and loan guarantees for energy efficiency improvements and renewable energy systems, as well as grants for energy audits and renewable energy development assistance.
- USDA's Farm Bill Programs at www.nrcs.usda.gov, including Environmental Quality Incentives Program (EQIP) help farmers, ranchers and forest landowners meet environmental challenges on their land through financial, educational and technical assistance.
- Contact your local utility to understand current lighting incentives and training opportunities. If in Oregon, Energy Trust of Oregon is a useful resource.
- The Oregon Department of Agriculture has a good website on energy conservation and generation opportunities for agriculture. www.oregon.gov/ODA/energy.shtml.
- The National Sustainable Agriculture Information Service Web Site includes a wide variety of energy-related publications, success stories, and links on energy efficiency and renewable energy opportunities. http://attra.ncat.org/attra-pub/farm_energy/.
- A variety of agricultural energy conservation and generation publications are available on the Oregon State University extension Farm Energy page. This site is part of a collaborative effort by land grant universities to share research-based knowledge on a variety of topics, including energy. Publications available on the site include selecting and maintaining greenhouse thermostats, wood heat for greenhouses, and efficient lighting. www.extension.org/ag_energy.
- Additional information on the incentive programs described here is available on the Climate Friendly Nurseries website at www.climatefriendlynurseries.org.

State of Oregon Incentives

Energy Trust of Oregon (ETO)

ETO offers incentives for commercial, agricultural and industrial customers of any one of the state's investor-owned utilities to increase the energy efficiency of their existing buildings. The project site must be located in Oregon, and serviced by Portland General Electric, Pacific Power, NW Natural Gas, or Cascade Natural Gas. The standard incentive program provides specific rebates for the retrofit of such equipment as electric motors, irrigation equipment, lighting, insulation, compressed air and HVAC equipment. Projects must be pre-approved before making any equipment purchases or initiating any work.

Business customers retrofitting existing buildings through measures not covered under the standard incentive program can receive financial assistance from ETO through the custom incentive program. To qualify for a custom incentive, the energy savings must be at least 25 percent of the current energy use for lighting equipment and 10 percent for all other equipment and measures.

Oregon Conservation Tax Credit (CTC) and Small Renewable Energy Grant Program.

Until June 2011, Oregon provided significant tax credits to businesses for energy conservation and renewable energy projects through the Business Energy Tax Credit (BETC). The BETC has now ended. However, Oregon will continue to invest in business energy conservation and renewable energy projects through two new programs. The Conservation Tax Credit (CTC), like the old BETC, provides a tax credit worth up to 35 percent of costs for an energy efficiency project. The CTC is capped at $28 million for the 2011-2013 biennium, so early application is encouraged before the cap is reached. The Small Renewable Energy Grant Program will provide grants to businesses for small-scale renewable energy projects. Learn more about both programs as they are developed by signing up for email updates at www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml.

Federal Tax Credits and Treasury Grants

The federal government offers a number of tax credit incentives for businesses. A few of the programs are described below, but businesses are encouraged to view a detailed list of both state- and federal-level programs found online at the Database of State Incentives for Renewables & Efficiency (DSIRE, at www.dsireusa.org. Applicable tax forms may also be found at DSIRE.

Federal Rural Energy for America Program (REAP)

The federal REAP, enacted as part of the Food, Conservation, and Energy Act of 2008 (H.R. 2419), promotes energy efficiency and renewable energy for agricultural producers and rural small businesses through the use of grants and loan guarantees for energy efficiency improvements and renewable energy systems, as well as grants for energy audits and renewable energy development assistance.

REAP funds are available to agricultural producers and small businesses to purchase renewable energy systems, to make energy efficiency improvements, and to conduct relevant feasibility studies. Grants are limited to 25 percent of a proposed project's cost, and the loan guarantees for up to 50 percent (loan guarantees may not exceed $25 million); the remaining 75 percent of the project's cost must come from non-federal sources including loans, investors, or any available state or local grants. The size of the grant awarded can be anywhere from $1,500 to $250,000 for energy efficiency projects; for renewable energy systems, grants of between $2,500 and $500,000 are awarded. No person or entity can receive more than $750,000 from multiple projects.

Farm Bill Programs

The Farm Bill's conservation programs help farmers, ranchers and forest landowners meet environmental challenges on their land through financial, educational and technical assistance. Relevant programs are described below.

Information on all Farm Bill programs can be found at www.nrcs.usda.gov.

Environmental Quality Incentive Program (EQIP)

EQIP is one of the largest landowner incentive programs, and offers financial, educational and technical assistance for conservation practices such as efficient fertilizer and pesticide use and irrigation efficiency Administered by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), EQIP pays up to 50 percent of project costs and up to 90 percent for limited resource and beginner farmers.

Conservation Stewardship Program (CSP)

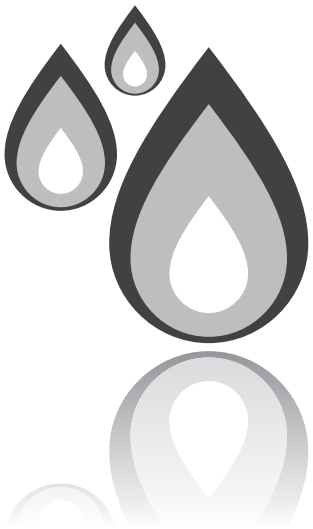
The Conservation Stewardship Program gives financial assistance to farmers and ranchers in the form of incentive payments to conserve and enhance natural resources on working agricultural lands. This program is very broad -- it can address nearly any environmental issue related to land management on any type of farm or ranch in any state. This program is innovative in that it marks the first time a Farm Bill program has rewarded farmers and ranchers who have already established their own high standards for environmental performance; landowners already strip-cropping (which protects soil against erosion and helps keep sediment and farm chemicals out of watersheds), for example, may be eligible for payments. Depending on the resource and the breadth of the program in your agricultural operation, initiatives may be eligible for up to $45,000 annually for terms of 5 to 10 years.

Renewable Electricity Production Tax Credit

This corporate tax credit is available to commercial and industrial sectors and covers renewable energy projects relating to landfill gas, wind, biomass, hydroelectric, geothermal electric, municipal solid wastes, hydrokinetic power, anaerobic digestion, small hydroelectric, tidal energy, wave energy, and ocean thermal energy.

Federal Renewable Energy Grants

The U.S. Department of Treasury offers grants that may be awarded for new renewable energy installations in lieu of the Business Energy Investment Tax Credit or the Renewable Electricity Production Tax Credit. It is applicable in commercial, industrial, and agricultural sectors, and covers 30 percent of property that is part of a qualified facility, including fuel cell property solar property, or small wind property. The grant program additionally funds 10 percent of all other property. Detailed program information can be found online at www.dsireusa.org.



Guide Methodology

Best Management Practices Selection

This guide highlights seven strategies that will capture high resource and cost savings for the upfront capital incurred, in addition to providing general descriptions of numerous opportunities for reducing your resource consumption and GHG footprint. The measures described in this guide include both low-cost/no-cost opportunities as well as larger capital projects.

To select the best management practices with the largest opportunity for resource and cost savings, we first considered the relevance of each measure to nursery operations throughout Oregon. We then estimated each practice's potential return on investment (ROI, or the net savings divided by the cost). We then prioritized best management practices by applicability, energy efficiency ROI and GHG mitigation ROI, and were able to establish the practices with the highest potential for nurseries as a group.

To their credit, many nurseries have already implemented a number of best management practices and should be recognized for their commitment to resource efficiency. While we have chosen to draw attention to these particular best practices, there are a multitude of management strategies with good potential for saving money, time, and resources; many additional opportunities are referenced in the "Low-Cost/No-Cost Opportunities" and "Best Management Practices Requiring Upfront Capital" sections of this guide, and there are other options beyond those included here. It is important to note that the practices with the highest potential for some nurseries may not work for others due to the variety of nursery parameters, infrastructure and operations throughout the industry. This guide, therefore, comprises a menu of options to consider implementing, and should serve as a starting point for further investigation. You can find the most up-to-date recommendations and information at www.climatefriendlynurseries.org.

Presentation of Savings Potential

This Best Management Practices Guide was designed to speak to all nurseries throughout Oregon, which comprises a very diverse group of businesses in terms of size, age, type of nursery operations, products sold, and level of efficiency. While the measures included in this guide have the potential to generate savings for all participants, it was necessary to maintain a general level of detail regarding cost and savings potential because the results will be different for each nursery. For example, a large nursery with inefficient lighting will have a much larger cost and concurrent energy savings profile after implementing efficient lighting improvements than a small nursery that has previously upgraded some of their lighting systems.

To give some context for nurseries considering further analysis of the seven highlighted measures, we therefore present a general range of cost, savings potential, and payback for two sizes of nurseries—one that is 40 acres, and another that is 400 acres. The actual cost and savings potential for each nursery will invariably be different than any others; our presentation of cost and savings potential here is solely to give nurseries some idea of the size of each opportunity. To additionally offer some guidance regarding all of the opportunities listed in the "Low-Cost/No-Cost Opportunities" and "Best Management Practices Requiring Upfront Capital" sections of this guide, we rate the energy efficiency opportunity, GHG reduction opportunity, and applicability to nursery operations for each measure included in this guide with a "high," "medium," or "low" rating.

Model Nurseries: Potential Savings and Payback

To further demonstrate resource and cost savings potential for the seven highlighted best management practices in a way that will be as meaningful as possible for all nurseries utilizing this Guide, we have created a working document that presents two fictitious model nurseries with specific parameters; for each of the seven measures, we present costs and savings according to these model scenarios. By providing savings calculations captured by a nursery with a certain set of parameters, nurseries will have the opportunity to gain a general sense of the savings they can derive by implementing each measure at their own facility. The model nurseries can be found at www.climatefriendlynurseries.org.

While these model scenarios are completely fabricated, we used our interaction with CFNP participants and vetted our work with industry experts to ensure that they were realistic and meaningful in nature. We continue to do so in order to present data that is as close as possible to actual nursery operations, and in the spirit of continuous improvement, we welcome your feedback and commentary on our results (please see page 4 at the beginning of this document for contact information).

GHG Inventory Tool

We have also developed a GHG Inventory Tool as part of the CFNP, which enables a nursery to track its energy and resource usage and GHG emissions footprint, and measure reductions over time. Measuring energy and resource usage can present savings opportunities that were not previously apparent. Nurseries can download this tool at www.climatefriendlynurseries.org.

Next Steps

The information provided in this Best Management Practices Guide is high-level in nature; as discussed in the "Methodology" section, the diverse infrastructure configurations of the nurseries using this guide gives rise to the need for additional number-crunching. This guide should therefore be used as a starting point only; nurseries must complete a more detailed quantitative analysis for each potential measure prior to adoption in order to determine its cost effectiveness and savings potential.

Online Tools and Calculators

There are a few options that nursery managers can use to vet the opportunities mentioned in this guide. The first is to utilize the do-it-yourself calculators available online. There are a number of tools available on the Web that allow you to input parameters particular to your nursery and building systems; these will then calculate the estimated capital investment required as well as the expected energy and cost savings from implementation. You can find an extensive list of links to these calculators at www.climatefriendlynurseries.org.

Public online tools tend to be simple and straight-forward to use, and are readily available to anyone looking to examine an efficiency opportunity. However, these tools can also be somewhat limiting: it is difficult to identify the tools' author, and data reliability can be a real concern. Calculations are also generally fairly simplistic in nature, and do not often take all of the complexities of nursery operations into account when deriving savings and payback estimates. The tools listed above should therefore be used as a starting point, and additional analysis should be completed before project implementation.

Onsite Audits

Onsite audits offer an opportunity for nurseries to obtain site-specific information regarding efficiency measure opportunities. Audits come in many shapes and sizes. Depending on the level and depth of analysis you'd like to receive, you may opt to select one of the following types of audits:

- **Walk-through Audit.** These audits are often offered by utilities' efficiency programs for no- or low-cost. The auditor will take a quick tour of your operations and will give general recommendations regarding opportunities they notice that are likely to save money and resources. Because auditors generally do not collect data specific to your equipment and operations, results tend to be fairly generic and high-level in nature.
- **Engineering Audit.** Expert staff (either engineers or resource/energy efficiency experts) will analyze resource usage and consumption patterns and will collect data on your nursery's specific equipment parameters prior to coming on site. They will then tour your facilities with a site or operations manager and will spend a good amount of time becoming familiar with your facilities systems, as well as the human aspect of how resources are consumed. The auditors will then compile recommendations based on your nursery's consumption patterns and. equipment usage; they will suggest specific changes, outlining equipment types and deriving cost and savings estimates based on all of the site-specific information they collected.

- **Investment-grade Audit.** Investment-grade audits are completed by an energy professional or licensed engineer, who will assess your particular site, building systems and business operations to develop the best possible plan of action. The investment-grade audit provides a dynamic model of energy use characteristics of both the existing facility and all energy conservation measures identified; because the recommendations are so in-depth and therefore costly, companies tend to identify one or two measures to focus on. Site analysis is calibrated against actual utility data to provide a realistic baseline, from which operating savings for proposed measures are calculated. The energy professional will also work with nursery personnel to understand both the characteristics of all existing energy-consuming systems as well as any variations in load profile and operating procedures that may occur throughout the year. In some situations, they may elect to install sub-meters to some systems in order to fully understand your nursery's resource consumption profile. The result of an investment-grade audit is a report containing all information required to implement the measures in question.

The cost for audits varies widely. Walk-though audits are the least expensive, but provide the least specific information. Engineering audits are more costly, but may provide enough site-specific information to make an informed decision on whether to proceed with implementation. Completing a professional investment-grade audit is a comprehensive and trustworthy way to capture all of the information necessary to move forward with highly technical projects, and is highly recommended prior to significant capital investment and project implementation. However, an investment-grade audit is the most expensive option. As a rule of thumb, for expensive investments you will want to pay for the level of information you need in order to make a sound business decision. For less expensive investments or for those with fewer variables to consider, go with a less expensive alternative.

Technical Assistance

In addition to the audits described above, there is extensive technical assistance that can be utilized for best management practice implementation. There are a multitude of contractors and product suppliers with a high level of expertise in the realm of resource efficiency and nursery operations that can assist you throughout the process of vetting and implementing efficiency practices. Many contractors can also help you take advantage of tax credits and other incentives.

There are also some organizations in the area that can assist in project analysis and implementation. OSU Energy Efficiency Center (eeref.engr.oregonstate.edu) offers technical assistance for energy efficiency improvements. Joseph Junker, Director of the OSU Energy Efficiency Center, can be contacted directly at junkerj@engr.orst.edu.

We'd like to thank the following nurseries for their involvement in the Climate Friendly Nurseries Project. Their participation in the program demonstrates their leadership in the industry and has provided us with valuable insight.

Alpha Nursery
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Eshraghi Nurseries, LLC
Evans Farms Landscape Co.
Fisher Farms
Heritage Seedlings, Inc.
J. Frank Schmidt & Son Co.
Mahonia Vineyards & Nursery
Monrovia Nursery
Native Grounds Nursery
Northwoods Nursery, Inc./One Green World
Tree Frog Nursery

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