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Sustainable Production Systems

Principles and Approaches for Optimizing Efficiency in Nursery and Landscape Businesses

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Introduction

Publications in the *Sustainable Production Systems* series discuss ways of pursuing sustainability in nursery production systems. Sustainable businesses are those that yield acceptable returns on investments, conserve natural resources, make positive contributions to the community, and create a workplace culture where employees feel safe, productive, and valued.

Businesses that strive for continual improvement in operational efficiency and workplace safety reach sustainability in meaningful ways. Outcomes can include better workplace and customer communication, reduced costs, increased productivity, fewer defects, less physical strain on laborers, fewer workplace injuries, and more satisfied customers and employees.

Most managers already give their operations close examination to continually improve the efficiency of current operations, but many forms of inefficiency are difficult to identify and eliminate, even for experienced managers. Examples include unclear or indirect lines of communication, unreliable availability of supplies, untimely equipment repair needs, and disorganized workspaces. Identification and elimination of hidden inefficiencies often require a fresh perspective and some creativity. This article discusses these and other forms of inefficiency and provides approaches to viewing current operations with a fresh perspective. Included throughout the article are practical examples for application in nursery or landscape businesses.

Several "continuous improvement" programs exist as comprehensive strategies for transforming a workplace and its operations. Many of these programs, such as Lean Management, or simply Lean, stem from the highly effective business operating approach developed by Toyota Motor Corporation. This article draws ideas from Lean philosophies and tools, but it is not a guide to full adoption of the Lean program, nor is it a substitute for fundamental Lean training.

Recognizing "Value" and "Waste"

Any approach to improvement should start with an understanding of the difference between "value" and "waste." This difference is the foundational principle of Lean and many other continuous improvement programs. "Value" can be described as "what the customer is willing to pay for," or in other words "what draws the customer to pay for a particular product or service." For example, customers chose products based on factors such as plant health, plant shape, timely deliveries, and excellent customer service. These and other factors determine whether customers purchase the product and the price they are willing to pay. Therefore, activities that directly increase the customers' perception of value in the product are called "value-adding activities." Value-adding activities include fertilization, pruning, and returning customer phone calls.

"Waste" is any activity or resource for which the customer is *not* interested in paying the cost. These activities may be necessary but must be minimized in efficient operations. Examples include paperwork, machine repairs, movement of people and materials, overproduction, and equipment changeover. Because these non–value-adding activities do not directly increase the customers' value of the product, their costs chisel away at the bottom line.

The overarching goal in pursuing efficient operations is to focus on value-adding activities, which increase quality of products and services while minimizing waste (non–value-adding activities and resources). Unfortunately, some forms of waste are essential. For example, customers do not select a product based on the quality of the company's accounting system, yet accounting needs to happen for a company to be successful in business. However, with some ingenuity, time spent on non–value-adding activities such as payroll processing or moving plant material from one location to another can be minimized to reduce associated costs.

Laying the Foundation for Improvement

When the shortcomings of a production system are obvious, managers may use a "fire-fighting" approach, in

which the greatest and most obvious inefficiencies are addressed as they appear. However, this emergency-response approach is often a relentless job and leaves many hidden forms of inefficiency unaddressed. Therefore, a plan is needed to better prevent and resolve problems and to create a workplace culture that drives continuous improvement. Included here are five critical objectives for the successful development of a new improvement strategy.

Objective 1. Engage employees in the improvement process

Efforts to increase operating efficiency are most successful when employees, especially those who actually conduct the activities in question, are involved in the problem-solving process. These individuals know first-hand the details of the activities being conducted and are often able to contribute some of the most valuable input. Their participation in the improvement process naturally leads to better implementation because changes are viewed as cooperative efforts rather than imposed mandates. Employees benefit too by seeing that they have the power to positively change their work environment.

Businesses that implement Lean tend to notice and encourage a shift in supervisor roles. In Lean operations, the role of a supervisor is less about directing instructions to workers and is more about seeking their input about problems and possible solutions and coaching new improvement events.

Involvement of people with diverse experiences and specialties during an improvement event prompts the sincere question, "Why do you do it that way?" These discussions reveal inefficiencies that otherwise go unnoticed. A certain amount of humility is required for individuals, in any level of expertise, to admit that their way may not be the best way, and this sometimes can be a difficult obstacle to overcome. In any case, improvement must always be approached with respect for all people involved and recognition that the problem is in the system, not the people.

The goal of fostering a culture of continuous improvement in the workplace will certainly fail if employees sense that they may be negatively impacted by anticipated changes. For example, workers may fear that gained efficiencies and reduced labor requirements will result in the loss of their jobs. Therefore, a policy of zero layoffs or time reductions due to gained efficiencies must be implemented and clearly communicated. Increased efficiency should be used for increased productivity, or freed-up labor should be redirected toward other new or existing value-adding activities.

Companies that anticipate necessary reductions in labor must make labor changes prior to improvement efforts and never in response to increased efficiency. Otherwise, future improvement efforts will be tainted with a lack of employee support.

Example 1: One method of encouraging employee feedback is the use of a suggestion board or box where employees can suggest improvements. These suggestions and their implementation should be discussed during employee meetings. The suggestion board or team process board can also include spaces for improvement efforts that are currently under way and those that have recently been completed. This visual display shows that employee feedback is truly valued and can lead to real changes.

Example 2: While requesting ideas for general improvement or solutions to a specific problem, managers can offer rewards to those whose ideas lead to valuable change. Group rewards are another option which can encourage greater collaboration and allow everyone to celebrate the successful completion of a team goal. Examples of incentives include free lunch with the owner, grocery or gas gift cards, extra vacation hours, or even a chance to "pie" the owner.

Objective 2. Define the "best" way

The Lean tool used to accomplish this objective is called "standardized work," which turns an unclear process into a well-defined system with predictable, desirable outcomes. Standardized work illustrates the conditions and actions that produce "optimal" productivity and product quality. Examples include optimal cutting height, equipment settings, work pace, etc. Simply put, standardized work shows the employee the best known way to complete a task.

A natural outcome of standardized work is increased consistency. Consequently, the appearance of inconsistent outcomes, such as product defects or reduced productivity, indicates that a problem has occurred and requires attention. On the other hand, if standardized work is not defined, problems remain hidden within a disorderly system and are difficult to address. Similarly, improvements will also become lost unless they are clearly established as part of a standardized system.

Further Lean education and perhaps consultation with a Lean expert is likely necessary to make meaningful progress in establishing standardized work on a broad scale.

Example 3: When flats of plants are not sold on schedule, maintenance is required to keep the plants at a reasonable height. A small stake marked with predetermined cutting heights can be pushed into flats to clearly show employees how much to trim (Figure 1). With heights labeled one through four, the manager can easily communicate the necessary level of trimming to crewmembers.

Example 4: Pruning tools should be regularly disinfected to avoid the spread of disease between plants. Containers used for disinfecting can be stored at the tools' point of use and clearly labeled with the steps of the sanitation process (Figure 2).

Photo: Winston Dunwell, University of Kentucky, taken at Green Leaf Plants, a Division of Aris Horticulture Inc. (Lancaster, PA)

Figure 1. Greenhouse crewmembers use a small stake labeled with four distinct pruning heights to consistently and correctly prune plants.

Photo: Winston Dunwell, University of Kentucky, taken at Green Leaf Plants. (Lancaster, PA)

Figure 2. Containers used to disinfect pruning scissors are clearly labeled with the proper steps of the sanitation process. The containers read: "#1 Debris Rinse"; "#2 Isopropyl 5 minutes"; "#3 Final Rinse."

Example 5: An essential part of disease and pest management is consistent scouting to identify and target pests as needed. However, even growers with the best of intentions may find that their "scouting" methods consist of casually scanning a production bed or quickly stopping at a small number of plants while busily conducting other tasks. Instead, it is important to develop and follow a well-defined scouting procedure, which must be made clear to those responsible for the task. A scouting form should be used to record observations. The summary of the scouting procedure could be laminated and glued to the back of the clipboard used during scouting (Figure 3).

Example 6: Process mapping can be used to clearly show the specific steps to be taken within a process (Figure 4). It is not a map of physical locations or physical movement; instead, it illustrates the order and connectedness of the steps and the person responsible for each task. Process mapping is a good way to create standardized work for office activities, although it can be used for a variety of tasks.

Example 7: At Green Leaf Plants, a new system for planting cuttings was established using a Lean concept called one-piece flow (further explained on page 14). With the new system, a weekly chart was created to illustrate the expected productivity throughout the week (Figure 5). The estimated productivity was calculated based on what was determined to be a brisk but comfortable work pace for the crew when using the new system.

Approximately every two hours, the team leader marks the actual level of productivity on the chart. A green mark is used if productivity matches or exceeds the goal, and a red mark is used if productivity is below the expected level. This chart, along with similar charts for other activities, is displayed in a location where it is visible to other crew managers. These charts communicate to each manager how things are going in other areas of the nursery. Members of those crews who are ahead of their targeted productivity can be reassigned to assist crews who are under the expected level of productivity. A recurrence of red marks indicates a greater underlying problem in the system that needs to be addressed.

Productivity charts can be used to identify and address problems in the system but should not be used to evaluate employee performance or create incentives. The latter use of the charts may tempt employees and even managers to cut corners to reach set goals rather than to address underlying problems.

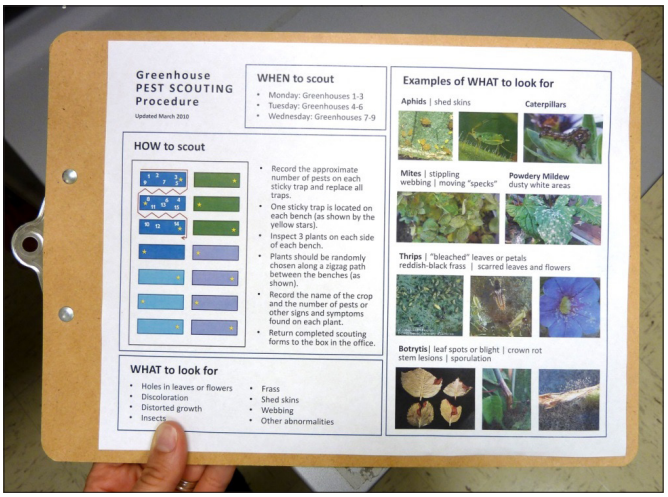


Figure 3. A clearly summarized scouting protocol is placed on the back of a clipboard used to record weekly scouting activities.

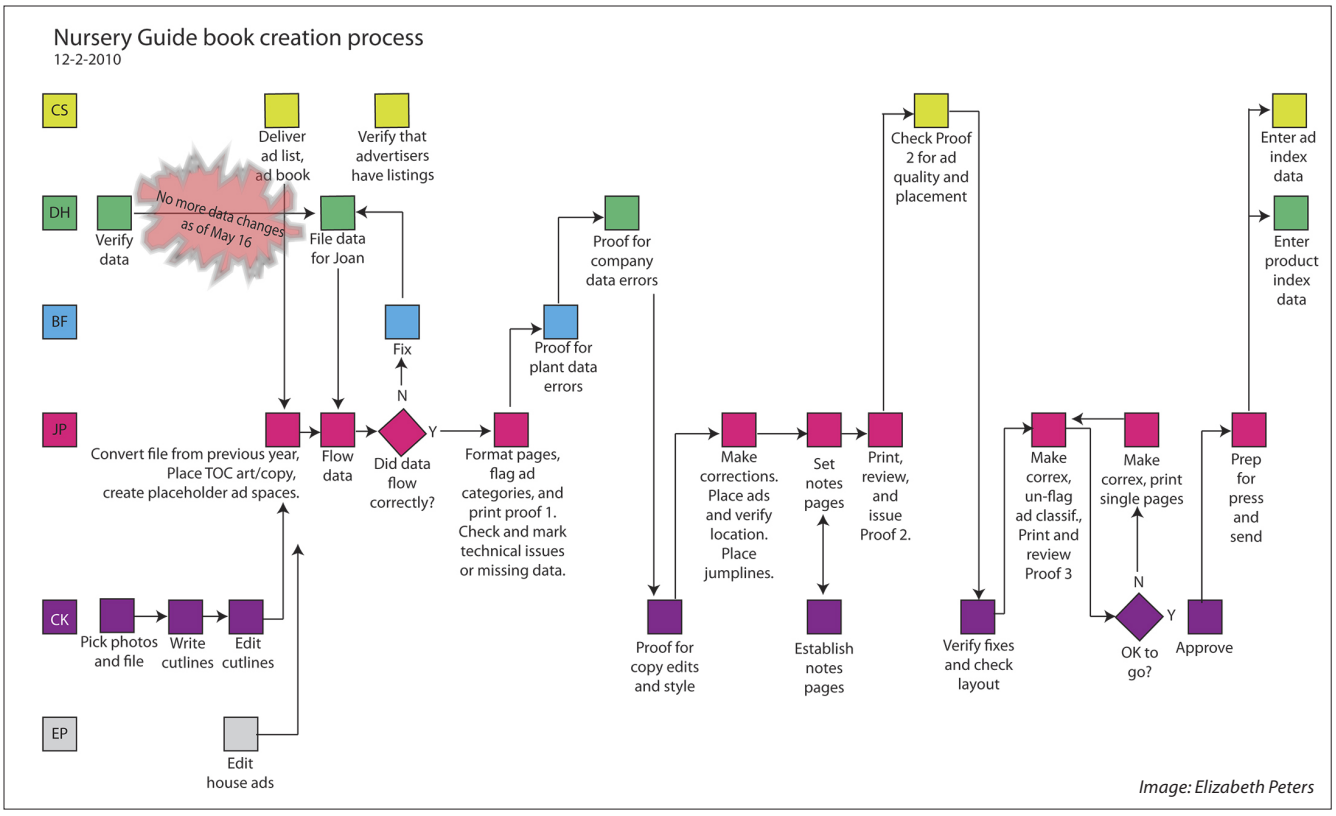
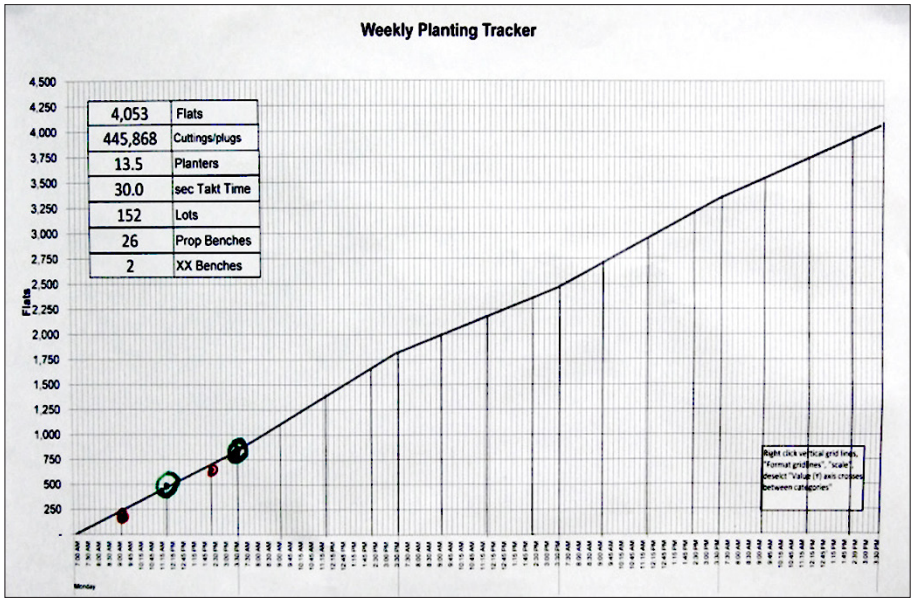


Figure 4. This process map was developed by the Nursery Guide team at Oregon Association of Nurseries in 2010 to create standardized work for the publication of their annual Nursery Guide. Each row/color represents a member of the team. Squares represent tasks. Diamonds represent decisions that determine the next step of the process.



Photos: Andrew L. Bishop, Green Leaf Plants. (Lancaster, PA)

Figure 5. A weekly chart illustrates the expected productivity throughout the week. A green mark indicates that productivity matches or exceeds the goal, and a red mark indicates that productivity is below the expected level. A recurrent appearance of red marks indicates a problem in the system that needs to be addressed.

Objective 3. Make systems intuitive for (new) employees

The aim of this objective is to make it as easy as possible for employees to do their job correctly, perhaps even to the point that it is difficult to do the work incorrectly. Managers should strive to set up a workplace and systems in which anyone could step into the operation and quickly understand how things work. If new employees are confused about common tasks or are fumbling around the workplace after days, weeks, or months on the job, this objective certainly requires some attention. However, even highly experienced employees benefit from changes that make the system more intuitive.

Written protocols are sometimes used to instruct employees on particular tasks, but visual controls are much more effective than written text alone. Visual communication uses color coding, symbols, charts, or various other

visual techniques to quickly communicate a concept. Traffic signs and lights, bar graphs, and weather forecast maps are examples of common visual cues. In the workplace, visual controls make new tasks intuitive to employees, but they speed up work done by experienced individuals as well. Consider the visual components in each of the examples 3 through 7, discussed above.

Example 8: A simple example of a visual control is the color coding of nuts and bolts on a piece of equipment to match the color coding on wrenches of coordinating sizes. This example is very practical for equipment that is repeatedly modified for different operations because it allows workers to quickly find the correct wrench when removing a nut or bolt. Additional examples of visual controls are discussed in the sections below, particularly in the section titled "Start with 5S."

Objective 4. Ensure safe working conditions

Workspaces that are cluttered and difficult to navigate not only hinder value-adding activity but create hazardous working conditions. Steps to remove and prevent workplace clutter are offered in the section titled "Start with 5S." Safety supplies such as first aid kits, eye-washing stations, and fire extinguishers, as well as emergency exits must be readily accessible and clearly marked with universally recognized signage. Similarly, workplace hazards must be minimized, eliminated or otherwise clearly marked with signage.

Objective 5. Plan to make it habit

Unfortunately, it is not uncommon for companies to make efficiency improvements only to have things return to their previous state after a few weeks or months. The biggest reasons for failure are a lack of engagement from the entire team (as discussed in Objective 1) and a lack of planning for sustained change. Provisions to solidify change and keep improvement efforts from becoming stagnant are critical for success.

Example 9: System changes should always be re-evaluated after their implementation. A standardized evaluation form can be used to find weaknesses in the new system and additional areas of improvement. Questions to consider are:

- Are the changes achieving the desired results? If not, why?
- Are employees following the new system? If not, why?
- Does the new system need additional tweaking or bigger changes? If so, how?

A tendency for employees to stray from the current standard work (the "best way") often indicates that the current approach may not actually be the best way to complete the task or perhaps the system needs to be made more intuitive, as discussed in Objective 2. Efforts to sustain improvements are further discussed in the section titled "Start with 5S."

Ideas for Getting Started

Provided here are various approaches and practical examples for improving operations. While specific examples may not apply to every nursery or landscaping firm, the general concept of each approach should.

Trystorm

When presented with a problem, many people naturally want to thoroughly analyze and discuss various solutions before making any decisions. This is a good thing except when expectations to find a perfect solution prevent action from being taken. Rather than being frozen by a fear of failure, it is better for those involved to adopt a habit of "trystorming," which incorporates an element of action into the brainstorming and discussion process. As much as is possible, ideas for process improvements should be tested immediately by implementing a rough model or a mock-up of the possible solution. For example, equipment or facilities that require physical alterations can sometimes be converted during trystorming with simple, spare materials such as cardboard, rope, tape, wire, etc., which can later be replaced with more durable materials if needed. Trystorming quickly demonstrates whether an idea is worth pursuing further, and it tends to generate more ideas and enthusiasm for real change. A positive change is more likely to occur when problem solving is a hands-on activity.

Start with 5S

Efforts to overhaul operations for increased efficiency can be a daunting task. However, a great starting point for any operation of any size or level of experience lies in "5S," a simple yet powerful Lean tool. 5S is a philosophy and a five-step process to simplify and organize the workspace. The general concept is that everything has a place, and a system should be used to keep everything in its place.

Disorganized workspaces can cause many common and often hidden forms of inefficiency:

- Employees waste much time trying to find and gather necessary items for a task.
- Employees are likely to forget a necessary item and must return to find it.
- If items are not found, a new replacement may be purchased, creating unnecessary expenses.
- The exact number of available supplies is unknown, so supplies are reordered with poor planning. An excess of supplies creates further clutter and wastes valuable space, while a supply shortage leads to work delays, especially if the shortage is not noticed until the supplies are most needed.
- A dirty workspace or dirty equipment conceals evidence of equipment maintenance requirements, such as leaking fluids, missing bolts, etc.
- A lack of signage for emergency items, such as fire extinguishers and eye-wash stations as well as hazardous conditions such as spills and chemical storage, creates an environment conducive to accidents and injuries.

Benefits of 5S include:

- Increased efficiency
- Intuitive systems for new employees
- Reliable availability of supplies
- Improved equipment maintenance
- Safer working conditions

5S gets its name from its five steps:

1. Sort
2. Set in order
3. Shine
4. Standardize
5. Sustain

Before beginning the 5S process, decide the scope of the initial project; otherwise, the project may stray into adjacent workspaces, creating an increasingly daunting project that is unlikely to get completed. It is best to achieve all five steps in one location before beginning 5S in other areas of the business.

Businesses should carefully select the best area for the initial 5S program. To achieve a successful 5S workplace, the scope of the initial project should:

- Be attainable
- Benefit various components of the company
- Have the potential for meaningful change

1. Sort—clean out the junk

During the first 5S step, "Sort," all items in the designated workspace must be evaluated and categorized as either needed or not needed. Items determined to be not needed are either thrown away or marked with a red tag and placed in a designated red tag holding area, perhaps because they can be sold or recycled or they are too large for the trash containers. Items in question can be marked with an optional yellow tag. All tagged items should be removed by a predetermined "remove by" date.

Before the sorting process begins, establish criteria for throwing out unneeded items. Some of the questions that should be considered are:

- What is the item used for?
- Why do we have it?"
- How often is it used?

The space needs to be equipped with trash bins, carts for removal of large items, red tags, and a small red-tag holding area.

2. Set in order—establish a permanent and identifiable home for each item

The next step of the process is to reorder the workspace to provide a permanent and easily identifiable home for every remaining item. This process should consider everything from trash containers and cleaning supplies to tools and equipment. One of the goals in this step is to organize items so they can be easily found, used, and returned to their proper place.

When determining the best location for each item, consider the purpose and frequency of its use. Materials that are frequently used for a particular task should be stored near their point of use when possible. Items that are rarely used can be stored in more remote locations.

Supplies and tools that are used together for common tasks should be stored together. Moveable work units, such as task-specific tool boxes or fully equipped mobile workstations can be assembled for frequent activities that require movement of personnel, supplies, or equipment (Figure 6). For multi-step tasks using numerous supplies or tools, items should be stored in the sequence in which they are used.

To avoid over-accumulation of supplies, storage spaces should allow for only the appropriate quantity of items. To determine the proper quantity to be stored, consider how often the supplies can be replenished and how many are typically used during that period.

Establishing a logical place for each item is a time-consuming yet rewarding task. However, rewards are only gained if the organizational system is maintained. An essential measure in maintaining the system is to clearly identify the proper location of each object, which is best achieved through the use of various visual controls described below.

Examples of visual controls:

- Floor markings. Floor-marking tape can be used to identify the proper location and position of items that sit directly on the floor. Examples include rolling plant racks, rolling workstations, pallets, trash containers, carts, etc. Floor markings can also show spaces that must be kept clear, such as emergency exits, common

Photo: Todd Ryan, Valley Hill Nurseries (Springfield, KY)

Figure 6. A cart is equipped with every item needed when using a welder, including everything from the welder, all metal working tools, safety glasses, and work gloves.

pathways, or the areas surrounding electrical panels, fire extinguishers, or eye-wash stations.

- Shadow boards. Items that are stored vertically on a wall or pegboard can be outlined on the wall using contrasting paint colors. The shadow figure of each item shows employees where materials should be returned. Because shadow boards illustrate which items are missing, they facilitate timely recovery of misplaced items (Figure 7).
- Foam boards and drawers. Similar to shadow boards, foam boards have defined cut-out shapes to fit specific materials. Foam boards are used in drawers as well as for vertical storage.
- Labels. Labels are placed on storage spaces to clarify which items belong there. Visual labels using clear symbols or images are often better than textual labels. For example, magnets in the shape of specific tools are commercially available for placement on individual drawers of metal storage units.
- Space for specific and appropriate quantities. Storage units that provide limited spaces or separate cells for individual items are used to prevent over accumulation of supplies. Use of such storage units facilitates supply ordering by clearly indicating the type and proper quantity of supplies that need to be reordered.
- Safety signs. Universally recognized signage should be used to communicate safety information, such as the location of fire extinguishers, eye-wash stations, first aid kits, emergency exits, slippery surfaces, chemical storage, and recent chemical applications.
- Color coding. Color coding can be used in a variety of ways to quickly communicate information. In one case, for example, use of color replaces textual labels to communicate that items marked with a dot of red paint belong in the red storage unit, items marked with a blue dot belong in the blue storage unit, and so forth.

Photos: Andrew L. Bishop, Green Leaf Plants. (Lancaster, PA)

Figure 7. Shadow boards show where items are properly stored and indicate which items need to be returned.

3. Shine—as a method of inspection

The third 5S step is to thoroughly clean the workspace by removing dirt, grease, and dust from all surfaces, especially machinery. The cleaning process can even include waxing floors, painting, upholstery cleaning, and pressure washing. These activities may seem irrelevant to efficiency improvement efforts, but maintaining clean equipment and workspaces provides significant benefits, including easier equipment inspections; increased equipment longevity; stronger mindset of workplace orderliness among employees; greater professional appearance for customers; and safer and more appealing working conditions for employees.

4. Standardize—create a routine

As previously mentioned, the rewards of establishing an orderly workspace are not truly achieved unless the organizational system is continually maintained. Continuation of the system requires some on-going efforts, but over time these efforts should become adopted as a permanent and valuable part of the workplace culture.

The most effective way to initiate adherence to the 5S system is the establishment of a 5S schedule (Figure 8). This schedule provides daily, weekly, or monthly assignments to reinforce and maintain the work done in the previous 5S steps. Assignments can be divided and rotated among personnel and should include a variety of tasks such as locating and returning any misplaced materials, general cleaning activities, restocking supplies, inspecting equipment, etc.

5. Sustain—perpetuate the cycle

Even after the unnecessary clutter is removed and a new organizational system is established, the 5S workplace always has room for improvement. Therefore, operations should continually readdress each step of the 5S system, beginning again with "Sort" and "Set in order". After the initial 5S efforts are completed and have gained some stability, the 5S system can be expanded to other areas of operation, such as production facilities, equipment maintenance shops, offices, etc. Companies that are serious about using 5S to improve workplace orderliness and efficiency should conduct regular 5S audits to evaluate their progress and recognize areas for further im-

5S Daily and Weekly Checklists UNIT: Maintenance Shop WEEK of _____

Employee A: _____ Please initial all chores when completed.

DAILY Chores:	M	T	W	Th	F	WEEKLY Chores: To be completed on Thursday or Friday	
1. Pick up trash						1. Take out all trash	
2. Replace tools in shadow boards						2. Mop floors	
3. Clear areas around exit doors, extinguishers, and eye wash stations						3. Clean and inspect machinery	
4. Clear walkways of debri; replace items according to floor markings						4. Clean dirty surfaces: walls, light switches, base boards, countertops, etc.	
5. Sweep floor-no oil, water or debri							

Employee B: _____ Please initial all chores when completed.

DAILY Chores:	M	T	W	Th	F	WEEKLY Chores: To be completed on Thursday or Friday	
1. Organize storage racks						1. Clean windows	
2. Roll up air hoses and extra extension cords						2. Dust windowsills, cabinets, and vents	
3. Check supplies inventory and notify office						3. Clean bathroom toilet	
4. Wipe up bathroom sink							
5. Restock bathroom supplies as needed							

Figure 8. A 5S schedule provides daily, weekly, or monthly assignments to reinforce and maintain the progress made during previous 5S efforts.

provement. A 5S audit systematically evaluates progress and adherence to the system in each of the five steps and shows current shortcomings. The audit asks questions such as:

- From what percentage of the work area have unnecessary items been removed?
- Which of the following describes the process for removing unnecessary items?
  - » A process does not exist
  - » A process exists but is not known by all employees
  - » A process is known but not used
  - » A process is used often
  - » A process is always used
- Visual cues are used in what percentage of the work area?

Examples of 5S audits can be found through the resources listed below.

As with any improvement effort, employees must be engaged in the 5S process. This involvement can be accomplished in part by providing 5S training to all current and future employees. An additional approach is to chart 5S audit scores and challenge the team to improve their scores with each audit.

Streamline Information Sharing

Inefficiencies in communication are a considerable source of hidden costs. Consider the process of telling crewmembers the tasks that must be completed during a morning, day, or week. Does the process reflect a children's game of telephone, in which information is passed through multiple people or unnecessary paperwork before reaching those who must complete the task? Furthermore, when the first task is completed, how do workers alert those that are responsible for completing the next step of the process? Consider also the time employees spend waiting for new instructions, either at the start of each work day or between tasks.

The goal is to create systems that make information readily available to those who need it, with little or no wait time. This is one area in which visual communication aids are often better than verbal and written communication. The following example shows how visual systems replace verbal and written communication to greatly improve operational efficiency.

Example 10: Green Leaf Plants

Business: Green Leaf Plants is a large wholesale producer of starter plants and unrooted cuttings. They produce a wide range of plants including perennials, annuals, herbs, ornamental grasses, and indoor potted plants.

Task: Green Leaf Plants follows multiple steps in the process of propagating their plants. These steps include planning, propagation, rogueing, moving plants from the propagation greenhouse to the growing greenhouse, maintaining plant quality, sanitizing empty beds, and programming mist for the next crop. These activities require much coordination among the lead propagator, crew leaders, and numerous crew members.

Procedures before improvement efforts: Computer-based scheduling programs and a series of printed work orders and reports were previously used to coordinate activities. Each step of the growing process was planned with a separate computer database.

Problems: The use of multiple computer databases made coordination of activities difficult. Furthermore, computer-generated plans often were not synchronized with the actual status of the crops; inconsistencies in weather and other conditions caused plants to progress somewhat more quickly or slowly than computer-generated schedules. These changes required scheduling updates and reprinting of plan reports. Consequently, hard copies of the plan were frequently out of date, causing confusion between employees and difficulties in coordination efforts. Employees were delayed by excessive paperwork in the form of work orders and reports and were therefore less available to complete essential value-adding tasks.

Solutions: Several staff members met over the lunch hour for a few days to discuss possible methods for reducing waste. As a result, a new and highly effective process involving flags and a white board chart was developed and implemented within eight days.

Flagging system: The movement of plants from the propagation house to the growing house is no longer initiated by a computer-generated schedule but by a green flag placed in the appropriate plots upon inspection and approval by the lead propagator. The green flag tells crewmembers that the group of plants is finished with the propagation process and is ready for removal of dead or inferior plants and transfer of quality plants to the growing area. Upon completion of rogueing, the crew places a red flag at the end of the row, indicating that all plots that are within that row and that have a green flag can be moved to the growing area (Figure 9). The moving crew then moves the appropriate plots to the growing area and places a checkered yellow flag in the newly placed plots. This indicates that the plot has recently arrived in the growing area and is ready for a standard post-propagation drench used to prevent disease and fungus gnat infestation. The drench crew then removes the checkered yellow flag upon completion of the drench.

Plants that remain in the growing area past the scheduled date of sale may need to be trimmed back. In this case, the lead grower marks the appropriate plots with a label indicating the proper cutting height and a white flag with the text "CUT" printed on it. When a member of the cutting crew finishes cutting a plot, the individual removes the label and flag and places them on top of the flat. This action indicates that the task has been completed and allows the team leader to find, inspect, and record the completed activity. The visual cues used in this process are summarized in Table 1.

White Board Charting System: To supplement the flagging system, a white board chart directs workers to the greenhouse benches that have flags and require attention (Figure 10). The white board gives a representation of each individual bench in the greenhouse and four possible work orders for each bench: 1) rogue, 2) move, 3) clean (sanitize benches), and 4) mist (plan misting program for the next crop). When the propagator places a green flag in a plot, he also places a magnet in the corresponding "rogue" box on the white board. The magnet indicates that the bench needs to be visited by the rogueing crew. Upon their arrival at the bench, the crew finds the flag(s) indicating which plot(s) on the bench should

Photo: Andrew L. Bishop, Green Leaf Plants. (Lancaster, PA)

Figure 9. The lead propagator places a green flag to tell crewmembers that the plot is finished with the propagation process and is ready for removal of dead or inferior plants and transfer of quality plants to the growing area. Upon completion of rogueing, the rogueing crew places a red flag at each end of the row, indicating that all plots in that row with a green flag can be moved to the growing area.

Table 1. Visual cues used to streamline processes and communication at Green Leaf Plants, Lancaster, PA

Process and Communication Cues				
Visual cue	**Who gives/ places the cue**	**Locations cues are placed**	**Meaning of cues**	**Who performs task/removes cue**
Green flag	Lead propagator	Flats in the propagation house	Flagged flats have completed the propagation phase and are ready to be rogued	Rogueing crewmember
Red flag	Rogueing crewmember	Row ends in the propagation house	All green-flagged flats in the row have been rogued and are ready to be moved to the growing greenhouse	Moving crewmember
Checkered yellow flag	Moving crewmember	Flats in the growing greenhouse	Flagged flats have recently been moved into the growing greenhouse and are ready for the standard post-propagation drench	Drench crewmember
White "CUT" flag and label with cutting height	Head grower	Flats in the growing greenhouse	Flagged flats (of unsold plants) require maintenance trimming	Cutting crewmember

be rogued then moved. After all "rogue" orders have been completed on a bench, the bench is marked with a red flag and the magnet on the board is moved from the "rogue" box to the "move" box. These boxes essentially serve as work orders, indicating what needs to happen next.

After the appropriate plots are moved from the propagation house to the growing house, the crew moves the magnet from the "move" box to the "clean" box, indicating that the bench needs to be sanitized. When that task is completed, the magnet is moved to the "mist" box, showing that the space is ready for the next crop and that the mist system should be programmed accordingly.

Crewmembers have made it a routine to update the white board together before breaks, lunch, and the end of the workday. The system is somewhat self-governing, because if workers forget to move the magnets, those responsible for the next activity "run out" of work orders and start asking questions about why the magnets have not been moved.

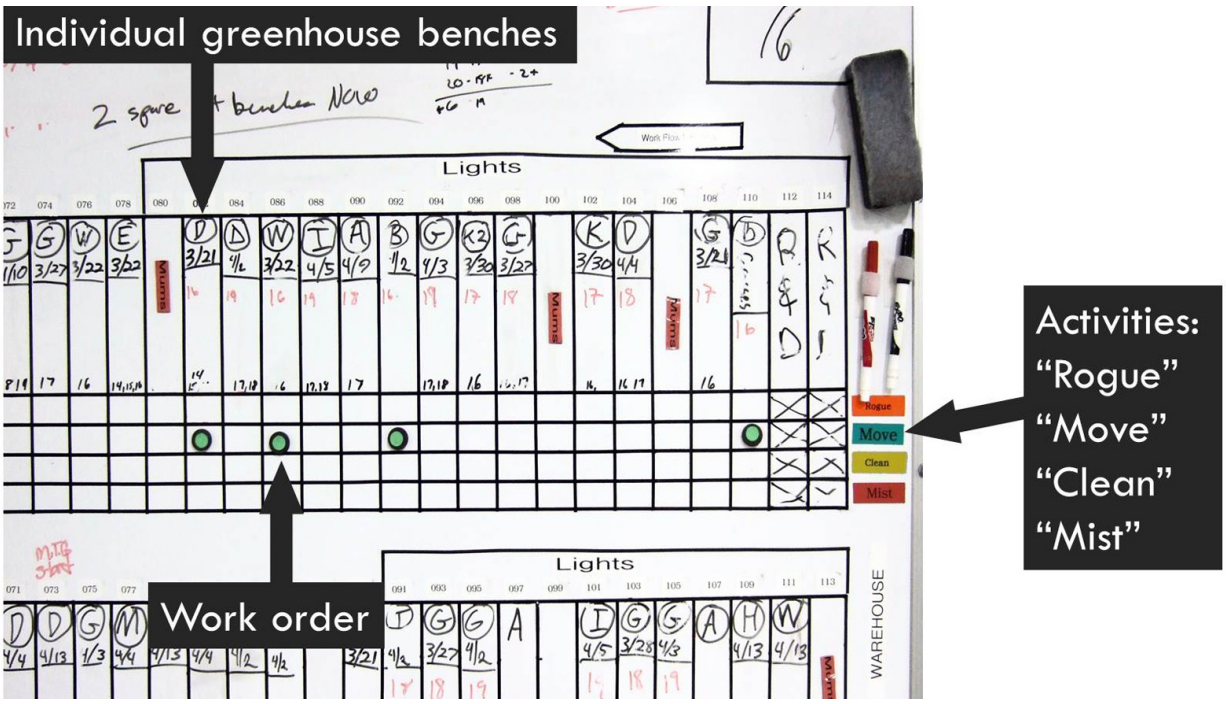


Photo: Andrew L. Bishop, Green Leaf Plants. (Lancaster, PA)

Figure 10. A white board is used to map activities in the propagation house; magnets on the board serve as work orders. In the image, magnets show that four benches have plants ready to be moved out of the propagation house.

Benefits: Staff members at Green Leaf Plants agree that the system brings numerous benefits because of its heavy use of visual cues rather than printed work orders, verbal instructions, and unreliable computer promptings. This new system allows anyone to walk into the area and know almost immediately what tasks need to be completed; employees do not wait for instructions or waste time with unnecessary paperwork. In effect, workers are creating work orders for one another without requiring any action by a supervisor. The system is extremely flexible and is nearly always current. Another benefit of visual cues is their ability to serve as a universal language, greatly lessening language barriers that can otherwise occur between employees.

According to the company's managing director, the flagging and white board system led to an immediate removal of about 25 to 30 hours weekly of unnecessary work while simultaneously increasing production capacity by about 20 percent.

Follow an equipment maintenance routine

Operations that rely heavily upon pieces of equipment benefit from committing to a routine equipment maintenance program. Equipment malfunctions create significant costs and operational delays, especially when they are only discovered at the time the equipment is most needed. A maintenance program should schedule and record appropriate preventive maintenance tasks for each piece of equipment, including oil and filter changes, lubrication, addition of engine coolant, tire rotations, battery changes, and equipment inspections for loose, damaged, or missing pieces, fluid leaks, or other problems (Figure 11). A system should also be put in place for employees to report unexpected problems or malfunctions so equipment can be repaired in a timely manner. No defect should ever go unaddressed or passed along for the next user to discover.

Maintain an appropriate number of supplies

A major delay can occur when there is an inadequate number of supplies for a necessary task. Running out of supplies creates delays when employees interrupt their tasks to retrieve additional supplies, or worse, wait for additional supplies to be ordered and shipped. A well-organized storage system is a good starting point for maintaining an appropriate number of supplies. Consider the approaches offered in the section titled "Start with 5S."

Example 11: At Green Leaf Plants, each pesticide product has a designated place on the chemical storage shelf with space for a few containers of each product. For each pesticide, the second container in line has a laminated tag clipped to it (Figure 12). This tag has basic information about the product and instructions to place the tag in a "re-order box" when the container on which it is clipped must be opened. This action tells the person responsible for supply ordering that the first container has been used and another container needs to be ordered.

Minimize unnecessary movements

In most nurseries, labor is the single largest (25% to 35%) production cost, and movement of plants, materials, and workers utilizes a large portion of that labor. In addition to high labor costs, many businesses face a shortage of reliable and skilled workers, which further heightens the need for increased efficiency in nursery and landscape businesses. By minimizing unnecessary movement of personnel, labor requirements are reduced and productivity and profits are increased. Furthermore, reductions in strenuous or repetitive movements reduce physical strain on employees.

Time observations and "spaghetti" diagrams can be useful tools to closely analyze worker movement and identify areas needing improvement. However, adequate dialogue and employee approval is key to prevent these detailed observations from making workers feel uneasy.

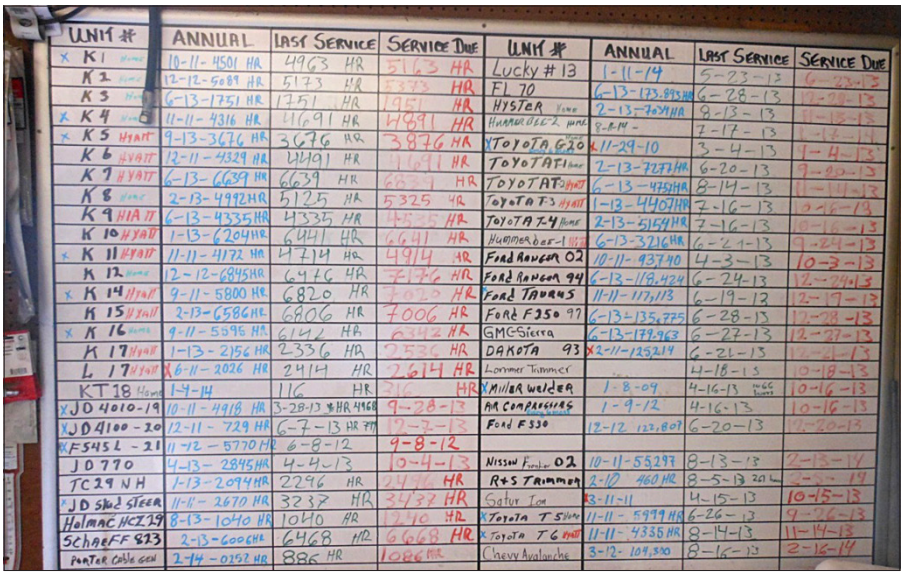


Figure 11. At Gold Hill Nursery (Hillsboro, OR), an equipment maintenance schedule is maintained on a white board and a digital spread sheet. The schedule includes the equipment name or number, the date on which yearly inspections are to be done, the date of the last routine service, and the date on which the next routine service is due.

Photo: Winston Dunwell, University of Kentucky, taken at Green Leaf Plants. (Lancaster, PA)

Figure 12. On a pesticide storage shelf, the first (front) container of each chemical product is partially used. The second container has a laminated tag with basic information about the product and instructions that state, "When opening a new container, remove [chemical name] card from container and place in Re-Order Box in Chemical Room."

To analyze the movement of an individual worker:

- Identify the basic work steps.
- Record the time taken for each step, separating "working time" from "walking, reaching, or waiting time."
- Create a bird's-eye (spaghetti) diagram tracking employee or equipment movement between or during each step of the process (Figure 13).

These three steps are completed separately for each employee involved in the process. Typically these steps are completed by one group while they observe the work being done by individuals in another group. However, it may be beneficial for the entire team to analyze the process via a recorded video, which can be paused and replayed as needed. This helps the group see details they may have otherwise missed. Live and recorded observations each have their own benefits, so a combination of the two might be best.

Spaghetti diagrams often look messy with back-tracking, crisscrossing, or duplicated efforts by multiple employees indicating an inefficient work flow. After inefficiencies are identified, improvements can be made through the creation of more efficient, standardized work. The purpose of recording the time taken for each step is to identify the points with the greatest inconsistency and waste and to measure the effectiveness of improvement efforts. Time recording can sometimes be used to coordinate activities that can or must occur simultaneously.

Waste in the form of movement occurs at all scales, including movement across the nursery, a single building, a room, or even a workbench. Many of the other concepts discussed above can reduce unnecessary movement, but because motion is a key form of waste, it should continuously be given great consideration. Examples below provide just a sample of practical approaches for minimizing non–value-adding movements.

Example 12: As previously mentioned, items that are frequently used together should be stored together at the location where they are used (point-of-use storage). Moveable workstations and tool kits assembled for specific tasks are great for common activities that require movement of workers, equipment, or supplies (Figure 6). These efforts reduce time spent gathering necessary tools, especially if multiple trips are made because something was originally forgotten.

Spaghetti Diagram and Time-Recording

Process: Small-order digging | Department: Nursery Production | Date Prepared: 5/28/13
Starting Point: Changing digging spades | Observed Employee: Field crewmember 1 of 3 | Prepared by: M. Allen
Ending Point: Leaving the field

Steps of the Process	Time
1. Help change spades	2:03
2. Get supplies from truck	:10
3. Set supplies in the field	:26
4. - Waiting on helper	:28
5. Prune rootball #1 + place basket	:22
6. Lower rootball - use spade	:13
7. Clean top of root ball	:11
8. Get rope	:08
9. Help tie the basket	:45
10. Get the spade	:05
11. Prune rootball #2 + place basket	:24
12. Lower rootball - use spade	:11
13. Clean top of root ball	:15
14. Help tie canopy of tree #1	:43
15. Pick up supplies	:32
16. Return supplies to truck	:39
17. Drive to next field site	
18.	
19.	
20.	
21.	
22.	

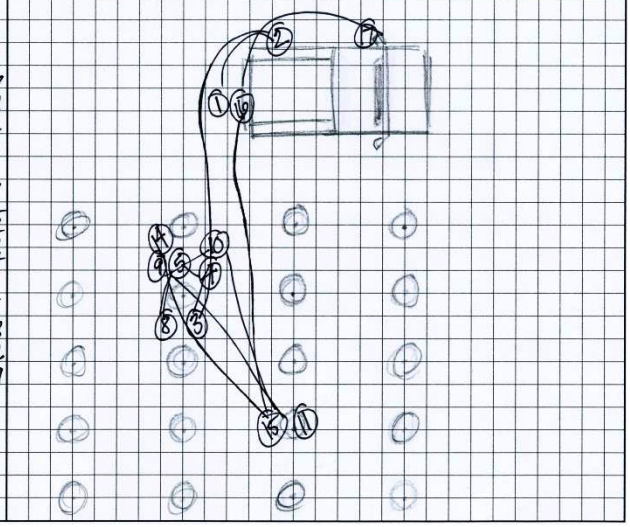


Figure 13. Evaluation of individual tasks can be done by listing and timing each step conducted by an individual and drawing their corresponding movements. This type of illustration is called a spaghetti diagram.

Example 13: Activities that involve continual cleanup of debris can be improved through simple workspace or equipment alterations that automatically collect debris into a waste container. To reduce clean-up times after messy plant-processing activities, leaders at Green Leaf Plants created new workstations with wire-latticed surfaces. Greenhouse production trays (flats) are processed at the workstations, and all debris automatically falls through the wire surface into collection containers below (Figure 14).

Example 14: In operations where equipment is repeatedly modified for different activities, efforts to streamline equipment changeover is highly beneficial. One landscape maintenance company organized an improvement event to address the time-consuming task of attaching and removing salt spreaders from their vehicles. Timely completion of these tasks is very important for companies facing unexpected and fast-moving snow or ice storms in the late fall or spring when vehicles are otherwise set up for other services.

Prior to the improvement event, the company's complete changeover from landscape operations to snow-management operations took approximately 46 combined man-hours. During the improvement event, a diverse group of employees (including three mechanics, an arborist, an administrative assistant, a salesperson, and an account manager) closely observed the process of attaching and removing a salt spreader. Their diverse backgrounds prompted many questions about why things were done the way they were done, which led to many new ideas for improving the system.

At the completion of the three-day improvement event, the team had successfully implemented a number of improvements that ultimately reduced the setup time for a large salter from 105 minutes to only 10 minutes; setup and removal times for both large and small salters were drastically reduced. The improvements included welding a "ski system" onto the bottom of the spreader to facilitate sliding the spreader into the truck bed; placing alignment racks in the truck bed to guide the spreader into the proper position; welding fork pockets onto the spreader so it could be picked up more easily while fine-tuning the alignment; and welding a stop bar on the bottom of the spreader to make a hard stop on the truck.

Taking the Next Steps toward Continuous Improvement

There is no simple recipe for creating an efficient operation, so those who are serious about making a complete system overhaul with substantial and long-term improvements should pursue further Lean education and network with experienced Lean users. After a broader Lean knowledge is achieved, overhaul of the system will likely involve tools such as value-stream mapping and one-piece flow, which are described in part below. These are just a couple of the various tools offered through Lean.

Value-stream mapping

Value-stream mapping is used to illustrate the overall flow of the product and information from the point of the supplier all the way to a finished product for the customer. Similar to process mapping described earlier, value-stream mapping does not produce a map of physical locations or physical movement; instead, it illustrates the synchrony of steps and their connectedness to one another. Value-stream maps are the starting point for looking at the system as a whole and identifying broad, non–value-adding activities that need the greatest attention.

The first value-stream map to be created is the current-state map, the purpose of which is to document the current processes and the flow of people, materials, and information between each process. It is not a map of what ought to be done; instead, it documents what is actually being done, even the obvious faults in the system.

Photos: Andrew L. Bishop, Green Leaf Plants. (Lancaster, PA)

Figure 14. Greenhouse production trays (flats) are processed at workstations with wire-latticed surfaces. This surface allows all debris to drop directly into collection containers below.

During this mapping process, inefficiencies will be found, and there will likely be a temptation to make immediate improvements. However, the fundamental purpose of the current-state map is to aid in the design of a future-state map (Figure 15). The future-state map presents an ideal system which the company will strive to achieve. It shows a bigger picture of the connectedness between each step in a process and the rhythm of the overall process. The goal is to create and sustain processes that flow smoothly with minimal waste.

It is better not to make changes until the future-state map has been completed and all downstream and upstream impacts are considered. With the completed future-state map serving as a roadmap, the company can begin making improvements, starting with individual activities that create the most waste. Approaches to value-stream mapping are thoroughly explained in the book *Learning to See: Value-Stream Mapping to Add Value and Eliminate Muda* by Mike Rother and John Shook.

One-piece flow: The bucket brigade line

One-piece flow can be difficult to imagine and achieve, but when put in place, it creates an efficient system with many benefits. Authors Jeffrey Liker and David Meier describe one-piece flow with the simple analogy of a bucket brigade line, in which a single piece (bucket) is passed directly from one individual to the next. Individuals work in synchrony to keep the buckets continually moving down the line. This approach differs from large batch processing, whereby, in the analogy given, one member of the line might move numerous buckets into a holding area before the next person begins to pass them along. Another familiar example of one-piece flow is a quick-serve restaurant that passes a customer's sandwich from one employee to another as the sandwich is made according to the customer's requests. One employee places the meat and cheese on the sandwich; the next employee adds the toppings, and so forth.

Although very common and sometimes more intuitive, batch processing actually tends to be less efficient than one-piece flow, except perhaps in operationswith only a very limited number of employees, each with primary responsibility for a broad range of activities. Drawbacks of batch processing can include:

- Degradation of inventory as it sits in a holding area
- Costly labor in moving items in and out of the holding area
- Quantities processed in earlier steps that do not reflect the number needed in later steps
- Inventory build-up that does not reflect customer demand
- Overhead costs for spaces that are used for storage, not value-adding activities

In contrast, one-piece flow keeps the product (or service) flowing smoothly through a process. It does not allow the build-up of inventory between steps in the process, and it is better able to provide the customer with the product they want, when they want it (Figure 16). One-piece flow, like many other standardized processes, makes problems in the system obvious, and therefore, easier to address.

A difficult component of one-piece flow is the synchrony required between each step of the process. If one person in the bucket brigade line drops their bucket, the rhythm of the entire process is thrown off and the process comes to a temporary halt. If buckets are frequently dropped, the entire system fails to function effectively. In most operations, perfect synchrony is

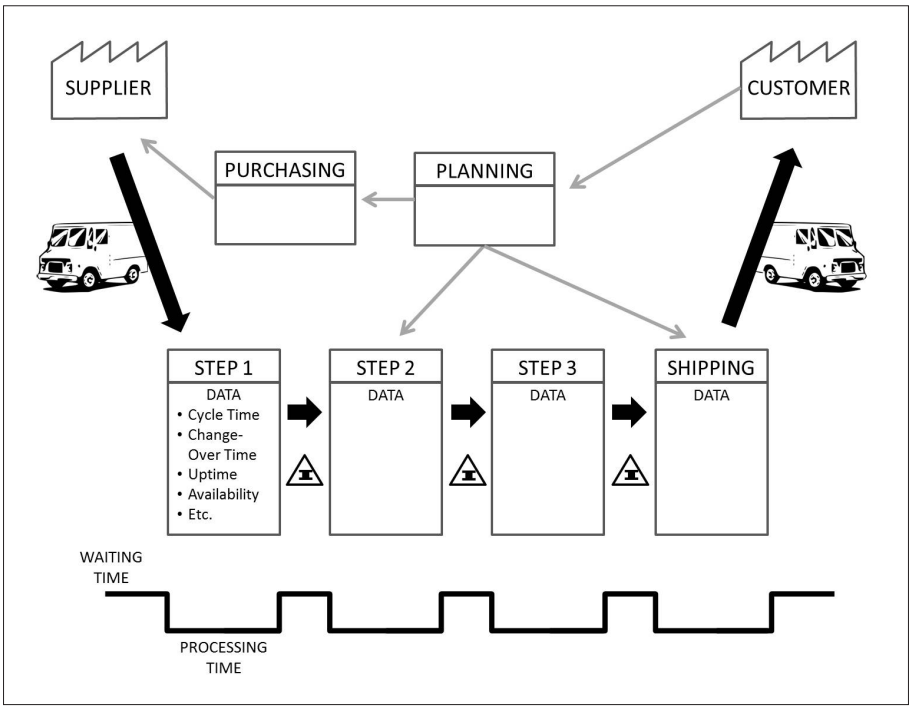


Figure 15. Value-stream mapping shows the exchange of information and materials through an entire process, beginning with the supplier and ending with the customer. This simplified template shows the key components of a value-stream map. Thin arrows represent an exchange of information. Thick arrows represent movement of materials. Triangles represent inventory. At the bottom of the map is a timeline showing: 1) the time materials spend "waiting" between each step and 2) the processing time spent on each step. In a completed map, the actual times would be written along the timeline in seconds, minutes, hours, or days. Additional data is typically listed in the boxes representing the steps of the process.

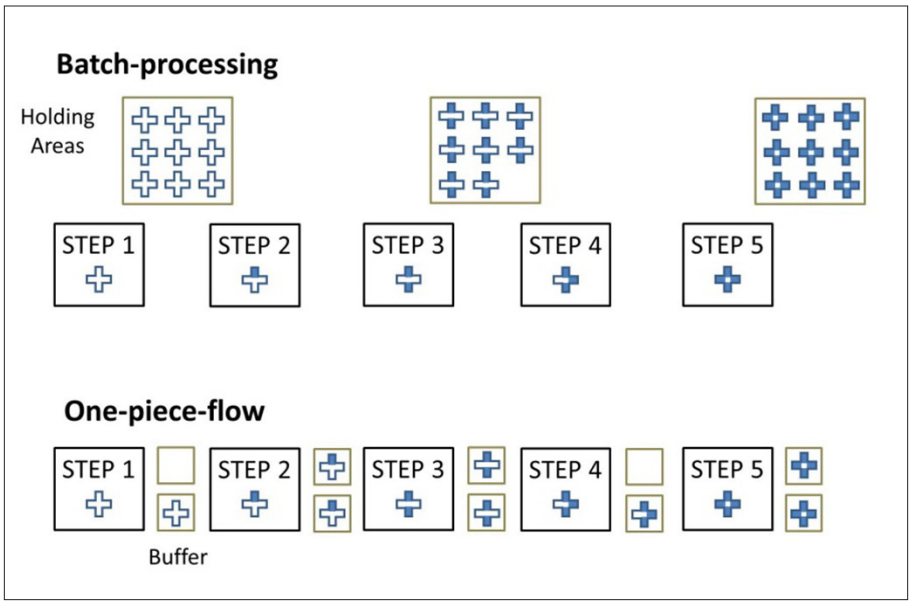


Figure 16. Unlike batch processing, one-piece flow does not allow the build-up of inventory between steps in a process. Instead, it keeps the product or service flowing smoothly through a process. One-piece flow uses a buffer to only allow space for a limited number of items between each step of the process.

impossible to achieve, so a buffer must be built into the system. This buffer is formed by creating a designated space for one or two pieces between individual workstations. This space allows for minor variances in each employee's working pace, but the limited space prevents the temptations of batch processing and stockpiling between individual steps of the process.

The example below better illustrates the application of these concepts in a horticulture production setting. However, it is important to note that one-piece flow is a tool that will likely require further Lean education and perhaps consultation with a Lean expert. It is not a recommended starting point for improvement efforts.

Example 15: Green Leaf Plants

Business: Green Leaf Plants is a large wholesale producer of starter plants and unrooted cuttings (see Example 10).

Task: Cuttings are stored in a cooler, planted in flats, and grown in a propagation greenhouse under mist irrigation.

Procedures before improvement efforts: Flats were previously filled with a growing medium by means of large batch processing. Filled flats were then temporarily stockpiled and later moved to the greenhouse benches for planting. Cuttings were removed from the cooler in large batches and planted directly into flats on greenhouse benches.

Problems: A number of problems existed with the previous planting system. First, stacking filled flats prior to planting led to compression of soil and plastic in the bottom flats and desiccation of soil in the top flats. Large batch processing led to discrepancies in the number of flats processed and the actual number needed.

Planting directly on greenhouse benches brought various inefficiencies. Workers were continually rearranging flats on the benches so finished flats were out of the way and the flats being worked on were directly in front of them. This continual movement of flats and an unordered planting system led to wasted movements and difficulties in keeping cultivars separated. Workers experienced unnecessary strain on their backs by leaning over benches.

Cuttings that were removed from the cooler and brought into the greenhouse in large batches spent an extended period out of the cooler before being planted, which compromised plant quality. Furthermore, when additional cuttings were needed, employees often stood waiting for one employee to return with a new batch of cuttings.

Solution: With some creativity and consideration of one-piece flow, the planting process was completely remodeled and moved into a warehouse at the nursery. Within the warehouse, a number of tables are set up as individual workstations, each with two workers sitting across from one another (Figure 17). Each table has two baskets of fresh cuttings, one of which is being planted from and the other waiting to be used when needed. Each worker has space for three flats at their workstation; on one side of the worker sits a flat filled with soil, waiting to be used; directly in front of the worker is the flat currently being planted; and to the other side of the worker is a finished flat waiting to be taken to the greenhouse.

Individuals sitting at the workstations continue planting cuttings, uninterrupted, while designated runners continually replenish workstations with the necessary supplies. One individual makes continual rounds with a cart of soil-filled flats and, as needed, places the flats at the workstations in the spaces designated for those flats. Another individual, the team leader, is responsible for removing finished flats from the workstations and replacing empty baskets with a full basket. Finished flats are placed on a cart that is taken to the greenhouse when it becomes full. The team leader also oversees the entire planting process to ensure things continue to run smoothly.

With use of a simple flagging system, the team leader can easily see when a basket of cuttings has become empty and needs to be replaced. Each table has a flag with a spring allowing it to be pressed against the table and stand up straight once released. Filled baskets are first placed on the table over the horizontal flag. When the workers empty

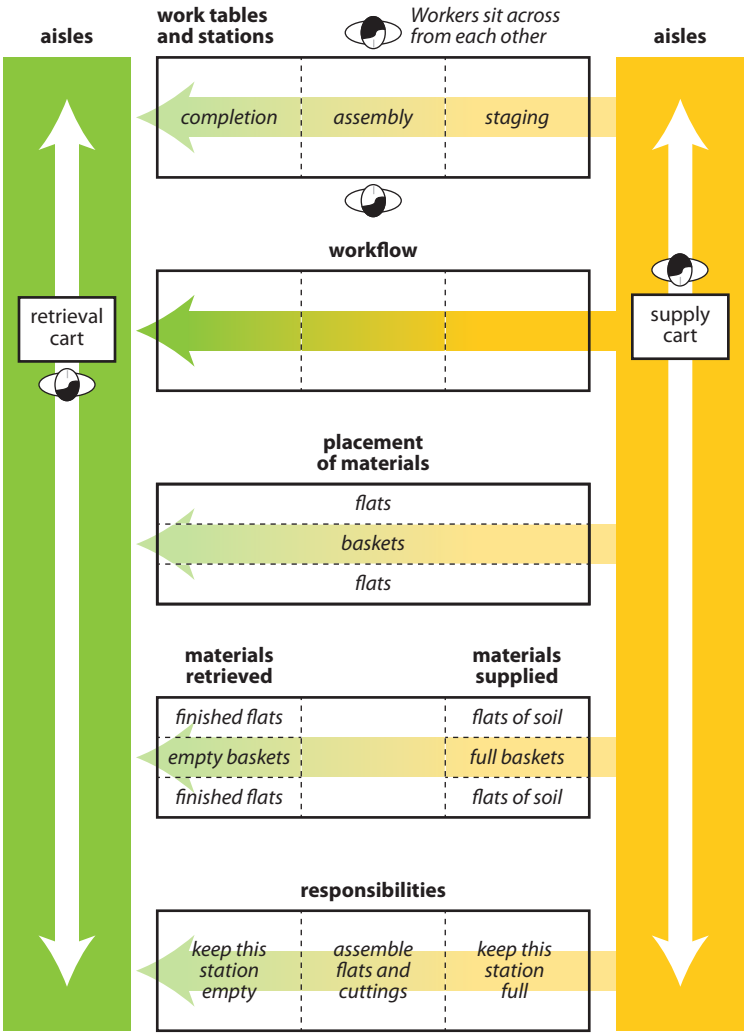


Figure 17. Cuttings are planted using the concept of one-piece flow. Multiple workstations are set up with two workers at each station and a basket of fresh cuttings placed at the middle of each station. Each worker has space for a maximum of three flats: at one end of the table is space for one flat of soil waiting to be planted; in front of the worker is a flat currently being planted; and at the other end of the table is space for one finished flat. Finished flats are continually picked up by the Team Leader and placed on a cart to be taken to the greenhouse. Soil-filled flats are continually replenished by another individual. At each table sits a second basket of cuttings which is retrieved by the workers when the central basket becomes empty. Retrieval of the filled basket causes a flag to spring up and alert the Team Leader that a new basket of cuttings is needed. Illustration by Dennis Duross.

their other basket and retrieve the filled basket, the flag pops up, indicating that a new basket of cuttings is needed.

Benefits: The new planting process is remarkably efficient, providing significant increases in productivity and yield. According to the company's managing director, the process appears to be just as efficient as a potting machine but with substantially less initial cost. The new process allows flexibility in the number of workstations and workers occupied at a given time, depending on the required workload. Because each workstation can plant a separate crop, the system also provides flexibility in lot size and the number of different crops being planted simultaneously. Plant quality greatly improved with the new planting system because cuttings spent significantly less time out of the cooler before being planted and placed under mist irrigation.

Summary

This article presents new approaches for revealing common and often hidden forms of operational inefficiency relevant to the nursery and landscape industry. Ideas presented in the article are drawn from several philosophies and tools of Lean operating systems established by Toyota Motor Corporation. In no way does this publication provide a comprehensive overview of Lean. Those who are serious about creating a Lean operation with substantial and long-lasting improvements should pursue further Lean education and network with experienced Lean practitioners.

Companies interested in implementing Lean should remember that Lean is not a one-time fix-it approach, nor is it simply a cost-reduction strategy.

Instead, it is about creating a workplace in which learning, problem solving, and collaboration are encouraged among all employees. The outcome of Lean is a culture of overall continual improvement, primarily in the forms of increased efficiency, communication, safety, and product quality.

Resources for further Lean education can be found in the list of resources below.

Resources for More Information

5S for Operators: 5 Pillars of the Visual Workplace by Hiroyuki Hirano

Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy by Masaaki Imai

Lean Enterprise Institute website: www.lean.org

Lean Management for the Green Industry: An Operational Strategy that Delivers Value to Customers and Eliminates Waste, PLANET Crystal Ball Report #26

Lean Manufacturing Tools: http://leanmanufacturingtools.org

Learning to See: Value-Stream Mapping to Add Value and Eliminate Muda by Mike Rother and John Shook

The Pocket Kaizen Handbook by Kenneth W. Dailey

References

Bishop, A.L. 2012. Green Leaf Plants. Lancaster, PA. Personal communication.

Liker, Jeffrey K., and David Meier. 2006. The Toyota Way Fieldbook: A Practical Guide for Implementing Toyota's 4P's. New York, New York. McGraw-Hill.

Martin, James P. 2006. Lean Management for the Green Industry: An Operational Strategy that Delivers Value to Customers and Eliminates Waste. Herndon, VA. Professional Landcare Network. Crystal Ball Report #26.

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