Convenience Analysis of the Oregon Paint Management Pilot Program

by

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MP Advisor's signature

Abstract

The US Environmental Protection Agency estimates that approximately 10 percent, or 64 million gallons, of the architectural paint that is purchased annually in the United States is left over. This represents a disposal cost to municipalities of about $8 per gallon, or half a billion dollars per year. Oregon's Paint Product Stewardship Law, passed in the summer of 2009 and implemented in July 2010, is the nation's first manufacturer-financed program for managing leftover architectural paint. This program is currently undergoing evaluation, the results of which will be used to more effectively implement similar programs nationwide.

The objective of my project is to determine how convenient the drop-off locations are for Oregon residents, including those in both urban and rural areas, based on the travel time and distance to the nearest drop-off facility. This is an important consideration because the easier it is for residents to reach collection facilities, the more likely they are to participate in the program. I generated service areas, the area within a given time or distance of a drop-off location. I estimated the percentage of each census block's population that resides within the service areas as equal to the percentage of total road length in each block that is included in the service area. Based on this analysis, more than 90% of Oregon residents live within 20 minutes, or 15 miles, of at least one collection facility. This degree of convenience, however, is not evenly distributed throughout the state. The most underserved residents include those living in Gilliam, Douglas, Polk, and Lincoln counties. Fewer than 3% of Gilliam county residents live within 15 miles of a drop-off location, compared to 40% in the county with the next lowest percentage. Likewise, Douglas, Polk, and Lincoln counties have a low percentage of residents within 15 miles of a drop-off location and they have among the largest number of people, relative to other counties, outside of this service area.

In addition to analyzing convenience of existing drop-off locations, I have developed a Site Selection and Convenience Analysis tool to aid in the selection of drop-off facilities based on the same convenience criteria. This tool is flexible and adaptive. It can be used during the development of recycling programs in other areas to determine which set of potential drop-off sites provide the best access to residents or which potential drop-off sites best complement the existing network of drop-off sites. More generally, the tool can be used any time there is a need to select from a set of potential site locations, where the demand for these sites is estimated by census population data.

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Introduction

The US Environmental Protection Agency (EPA) estimates that approximately 10 percent, or 64 million gallons, of the architectural paint that is purchased annually in the United States is left over. This represents a disposal cost to municipalities of about $8 per gallon, or half a billion dollars per year [1]. This leftover paint is the single largest component of household hazardous waste (HHW) collection programs [2].

Since December 2003, the Product Stewardship Institute (PSI) has facilitated a national dialogue of over 200 participants to reduce the generation of leftover paint and to increase reuse and recycling opportunities for the leftover paint. This initiative is a collaborative effort involving representatives from industry, consulting, nonprofits, and all levels of government. If successful, the program will expand the market for recycled content latex paint, inform the development of paint management programs in all 50 states, and establish an important new model for product stewardship in the U.S., with implications for household computers, electronics, chemicals, pesticides, pharmaceuticals and other household hazardous wastes and consumer products [3].

The dialogue resulted in an agreement in October 2007 to establish a Paint Stewardship Organization, funded by a pass-through cost to consumers, to collect and manage the leftover paint [4]. This is an example of product stewardship, which the Oregon Department of Environmental Quality (DEQ) defines as "a principle that directs all participants involved in the life cycle of a product to take shared responsibility for the impacts to human health and the natural environment that result from the production, use, and end of life management of the product [2]." Product stewardship provides incentives to manufacturers and retailers to consider the entire lifecycle impacts of the products that they produce and/or sell with the goal of encouraging manufacturers to design products that are less toxic, use less virgin material, and are more durable, reusable, and recyclable [2].

Oregon's Paint Product Stewardship Law, passed in the summer of 2009 [5] and implemented in July 2010, is the nation's first manufacturer-financed program for managing leftover architectural paint. Qualifying paint includes oil and latex paint in 5 gallon or smaller containers that is intended for use in the interior or on the exterior of buildings. The program is expected to result in the reuse, recycling, energy recovery, or safe disposal of approximately 800,000 gallons of leftover paint each year, decreasing Oregon state and local governments' costs by an estimated $6 million annually [2]. Furthermore, collection services will be extended to areas that are currently underserved or that are completely lacking proper paint disposal locations because the law stipulates that the program shall "provide for convenient and available statewide collection of post-consumer architectural paint in urban and rural areas of this state [5]." It also stipulates that certain parts of the program, including the funding mechanism, the educational materials, and the costs and benefits should be evaluated and submitted to the Oregon DEQ by September 1, 2011, and annually thereafter [5]. The Paint Product Stewardship Initiative (PPSI) took this a step further in initiating a full program evaluation that will review the program from planning to design and implementation. The evaluation committee's results will be used to more effectively implement similar programs nationwide [4] and to provide insights on the use of product stewardship for environmental management [3].

The Paint Product Stewardship Initiative (PPSI) has identified 12 questions [6] that are critical to answer in order to determine the effectiveness of the paint management program and to make recommendations for improvements in Oregon and in states that follow. Any attempts to answer these questions should give special attention to presentation. Throughout the evaluation process, conveying usable, clear, and easy to understand information to the public has been a priority. Interactive websites, videos, graphics, and maps have all been used to dispense information to those interested in the workings of the program and the evaluation process.

Part of evaluation question 5 focuses on the degree of convenience that the program offers to citizens across the state [6] because the easier it is for them to reach collection facilities, the more likely they are to participate in the program. Convenience is an important consideration because time is a limited and scarce resource [7]. Researchers have long noted consumers' interest in saving time and effort [8]. Bliss [9] notes that consumers have the ability to travel but it comes at a cost of time, effort, and money. How far people will travel and to what inconvenience they will put themselves depends, among other things, on the type of merchandise involved [9], their temporal orientation, including perceived time scarcity and the degree to which they value time [10], and the perceived importance of the service. Consumers are likely to be more tolerant of inconvenience when using consequential services [11], those that are highly valued by consumers [12]. Another aspect that affects perceived convenience is the capacity for polychronic, or concurrent, time use, which enables people to accomplish several goals at the same time. This is preferred over monochronic time use, or one thing at a time, by consumers who view time as a scarce resource to be used carefully. Research suggests the need for service providers to offer consumers more opportunities to combine activities in order to reduce their perceived time costs [13].

Berry et al. [8] draw a distinction between goods convenience and service convenience. The former includes time-saving items such as frozen dinners and is not relevant to my project. Service convenience is relevant and can be defined as consumers' time and effort perceptions related to buying or using a service. It has two dimensions, time and effort, and it includes factors such as location, hours of operation, and credit availability. Consumers spend time and effort deciding on, accessing, transacting for, and benefiting from a service, the relative importance of which varies across situations, services, and consumers. They propose five types of service convenience: decision convenience, access convenience, transaction convenience, benefit convenience, and post-benefit convenience. These reflect different stages in consumers' activities related to buying or using a service. Perceived time and effort related to each of these types contributes to consumers' perceptions of overall service convenience [8].

The type of service convenience relevant to the Oregon pilot program is access convenience. Access convenience involves consumers' perceived time and effort expenditures to initiate service and/or be available to receive it [8]. For inseparable services, those that require the physical presence of the consumer, access convenience includes service facility locations, operating hours, parking availability, and remote contact options [14]. The fact that consumers must synchronize their availability with the availability of the service means that service inseparability heightens the importance of accessibility [8].

Objectives

My analysis will determine the degree of convenience that the existing drop-off facilities, those active as of January 24, 2011, offer to Oregon residents based on travel time and distance to access the closest drop-off facility. Results will be presented at both the state and county level and will also address discrepancies between rural and urban access.

In addition, I will develop a decision support tool, based on the Oregon convenience analysis, to aid in the selection of drop-off facilities from a set of potential facilities. This tool can be used during the development of recycling programs in other states and will allow the user to determine which facilities minimize the time or distance the public has to travel to access a drop-off facility, maximize coverage area so that people in both urban and rural areas have access to drop-off facilities, and minimize the number of facilities required to capture a certain percentage of the population.

The network of collection facilities in Oregon has already been developed so the tool will be usable primarily to aid in site selection in the states that follow. As such, the tool must be adaptive to different states, different priorities, and different stages of development (i.e., whether a network of collection facilities is being developed from scratch or whether additions are being added to an existing network).

Convenience Analysis

Methods

I designed and executed the convenience analysis of the Oregon paint recycling program and the related decision support tool using ArcGIS 10.0 [15]. Both the convenience analysis and the tool are examples of a network analysis. This is a spatial analysis technique that uses network data, Oregon roads in this case, to calculate the distance between points or nodes on the network. It is preferred over alternative techniques, including buffering and straight-line distance calculations, because it takes into account actual access routes, and thus gives a more realistic picture of the time or distance to sites [16]. I calculated the length of each road segment, as well as the time it would take to travel each segment, for all roads in Oregon, using the Census 2010 roads data [17]. The travel time was calculated as miles / speed limit * 60, where the speed limit was assumed according to the following speed limit assumptions (Table 1), which are based on the MTFCC code available from the Census 2010 technical documentation [18]. I geocoded (digitally mapped based on an address) all existing drop-off facilities and potential drop-off facilities using the 10.0 North America Geocode Service (ArcGIS Online). Sixteen of the 87 drop-off locations were geocoded incorrectly (18%), although most of these points required only minor adjustments. Additionally, there were 7 planned collection events where a city but not a specific location had been identified. I used the city center from Census 2009 [19] to represent these event locations in my analyses.

I created service areas, areas within a given time or distance of designated points, for all drop-off facilities that were active by January 24th, 2011. I created service areas of 5, 10, and 15 miles, as well as 5, 10, and 20 minutes. I overlaid these with statewide census block population data, from the 2000 Census [20]. Finally, I estimated the percentage of each census block's population that resides within the service area as equal to the percentage of total road length in each block that is included in the service area. Census tracts are subdivided into block groups, which are further subdivided into census blocks. They are designed to be small areas whose populations have relatively homogeneous

Table 1: Definitions [18] and speed limit estimates of road categories found in the census 2010 roads dataset [17].
The MTFCC (***M***aster address file/***T***opologically integrated geographic encoding and referencing system ***F***eature ***C***lass ***C***ode) defines the category of road. The route type (RTTYP) further subdivides these categories.

MTFCC	Feature Class	Feature Class Description	Speed Limit
S1100 *and* RTTYP = I	Primary Road - Interstate	These roads are generally divided, limited-access highways under within the interstate highway system, and are distinguished by the presence of interchanges. They are accessible by ramps.	60 mph
S1100 *and* RTTYP ≠ I	Primary Road – Not Interstate	Generally divided, limited-access highways under state management. Distinguished by the presence of interchanges. Accessible by ramps and may include some toll highways.	55 mph
S1200	Secondary Road	Main arteries, usually in the US, state, or county highway system. These roads have one or more lanes of traffic in each direction, may or may not be divided, and usually have at-grade intersections with many other roads and driveways. They often have both a local name and a route number.	45 mph
S1400	Local Neighborhood Road, Rural Road, City Street	Generally paved non-arterial streets, roads, or byways with a single lane of traffic in each direction. They may be privately or publically maintained, and include scenic park roads and some unpaved roads.	35 mph
S1500	Vehicular Trail (4WD)	Unpaved dirt trails where a four wheel drive vehicle is required. They are found almost exclusively in very rural areas.	25 mph
S1630	Ramp	Allow controlled access from adjacent roads onto limited access highways, often in the form of a cloverleaf interchange.	35 mph
S1640	Service Drive	Usually parallel limited access highways and provide access to structures along the highway. They can be named and may intersect with other roads.	45 mph
S1710	Walkway or Pedestrian Trail	Used for walking and are too narrow or legally restricted from vehicular traffic.	removed
S1730	Alley	Service roads that do not generally have associated addressed structures and are usually unnamed. It is located at the rear of buildings and properties and is used for deliveries.	removed
S1740	Private Road for service vehicles (logging, oil, ranches, etc.)	Roads within private property that are privately maintained for service, extractive, or other purposed. They are often unnamed.	35 mph
S1750	Internal U.S. Census Bureau use	Roads for Internal U.S. Census Bureau use.	35 mph
S1780	Parking Lot Road	The main travel route for vehicles through a paved parking area.	removed
S1820	Bike Path or Trail	Paths used for manual or small, motorized bicycles, that are too narrow or legally restricted from vehicular traffic.	removed

housing and socioeconomic characteristics [21]. This means that low density housing is unlikely to be in the same census tract with high density development, commercial areas, or other zoning designations. Therefore, using the proportion of roads within the service area to estimate the population within the service area is a reasonable estimate. Figure 1 shows and describes a hypothetical example of this calculation.

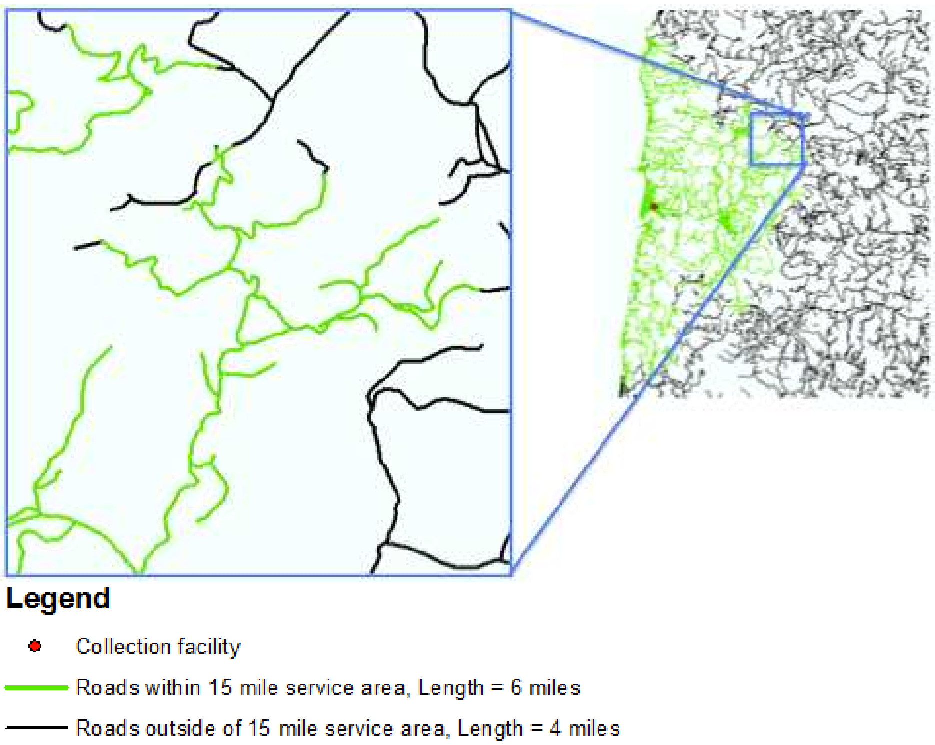

Figure 1: Hypothetical census unit demonstrating the population estimation within each service area.
This hypothetical census unit contains 10 miles of roads, 6 (60%) of which are within 15 miles of a drop-off location. If this census unit had a population of 200, I would estimate that 60% or 120 of its residents were within 15 miles of a drop-off facility.

Results

Collection facilities, active as of January 24, 2011, are distributed in clumps across the state. Very little area is located within 15 miles of a collection facility (Fig. 2).

However, Oregon's population is also heavily concentrated in a few areas with vast expanses in the center and eastern portion of the state that are sparsely populated (Fig. 3). About 52%, 77%, and 90% of Oregon's population is within 5, 10, and 20 minutes of a collection facility, respectively. Likewise, an estimated 70%, 84%, and 91% percent are within 5, 10, and15 miles of a collection facility, respectively. The 15 mile and 20 minute service areas are very similar so all further analyses used a 15 mile cutoff, which is about a 20 minute drive.

This high level of accessibility is not consistent throughout the state, however. Figures 4 and 5 (and Table A1 in Appendix 1) show the percentage of the population of each county that is within each of the largest calculated service areas, 20 minutes and 15 miles. These percentages do account for the fact that the nearest collection facility may be in a neighboring county. More than 90% of the population of 8 of Oregon's 36 counties is within 20 minutes of a collection facility and more than 90% of the population of 10 counties is within 15 miles. In both cases the highest percentage is in Multnomah County, which is home to the vast majority of Portland's residents. Fewer than 50% of the population of 4 counties, Polk, Lincoln, Wheeler, and Gilliam, are within 20 minutes of a drop-off location, and fewer than 50% of the latter three are within 15 miles. Fewer than 3% of Gilliam County residents are within the calculated 15 mile or 20 minute service areas.

Figure 6 shows the estimated number of people in each county that are not within 15 miles of the nearest collection facility. Lane, Douglas, Polk, and Lincoln counties have more than 20,000 residents each that are further than 15 miles from a drop-off location.

Conversely, Multnomah, Wheeler, and Sherman counties end the list, with fewer than 1000 residents each further than 15 miles away.

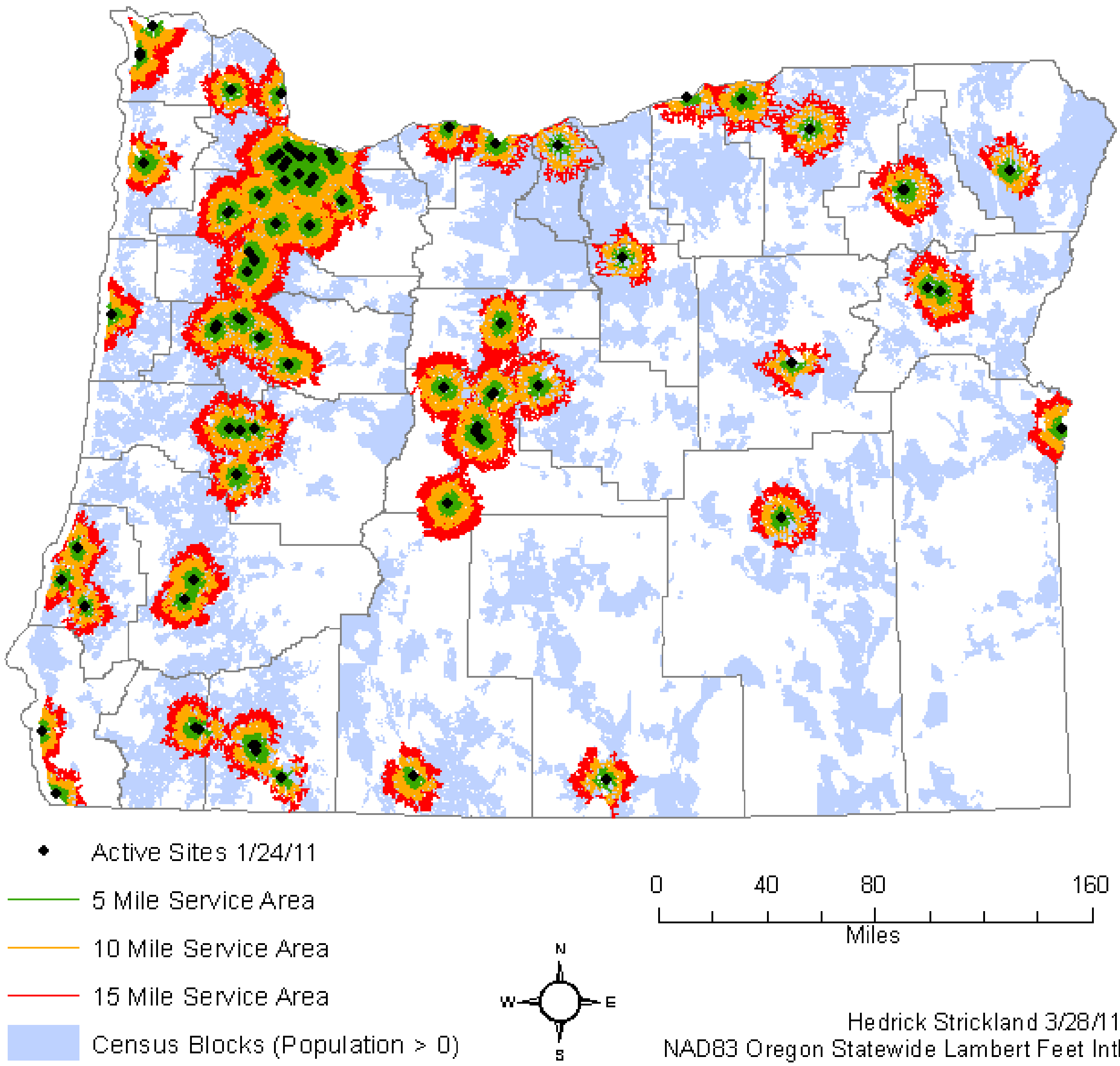

Figure 2: Five, ten, and fifteen mile service areas for Oregon paint management program collection sites that were active as of January 24, 2011 [17, 20].

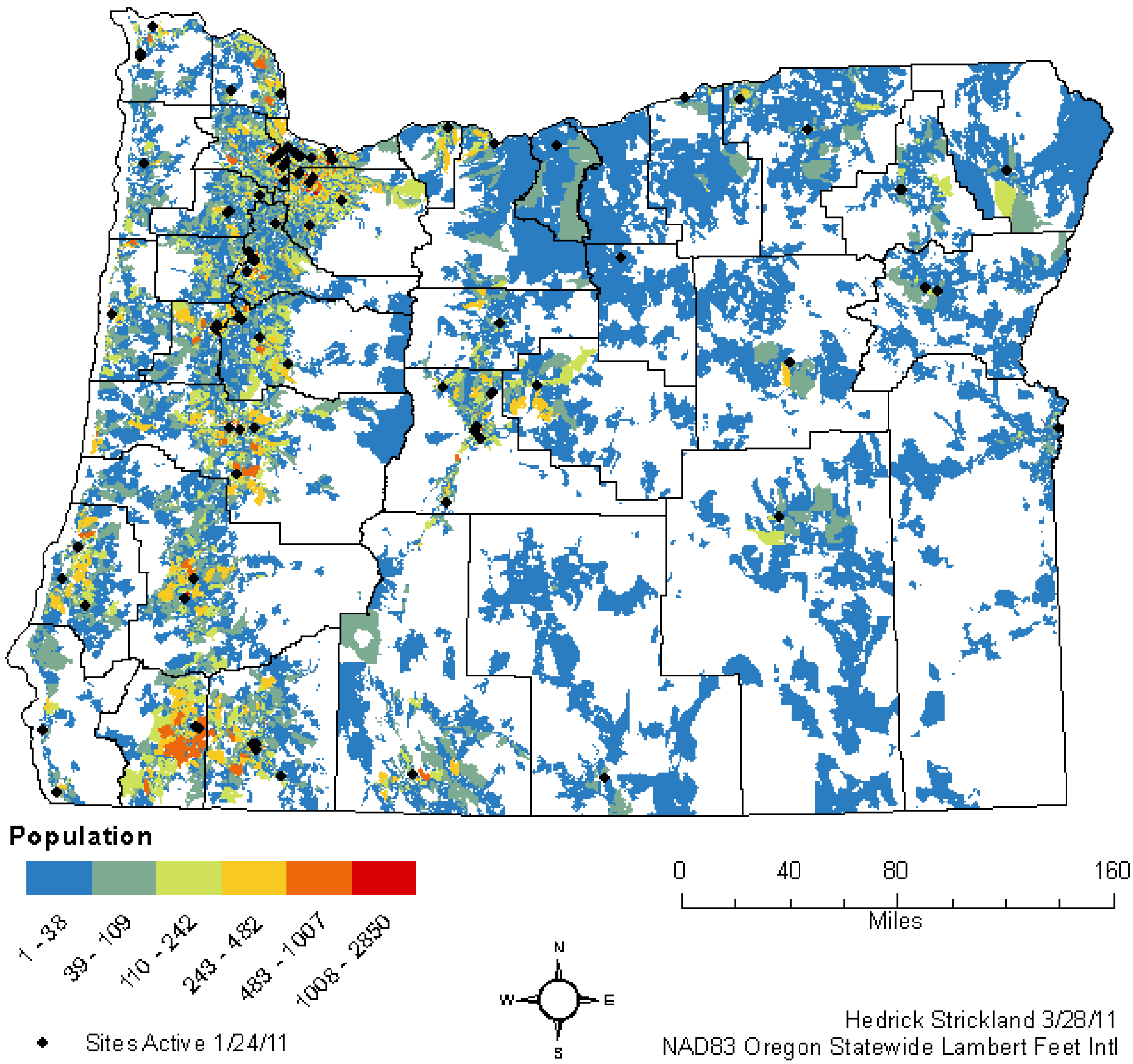

Figure 3: Population within each Oregon census block [20].
Blocks with no population have been removed to emphasize the vast expanses in the middle and eastern part of the state with little to no population. The population is heavily clustered in a patch in the center of the state and in a strip along the west side.

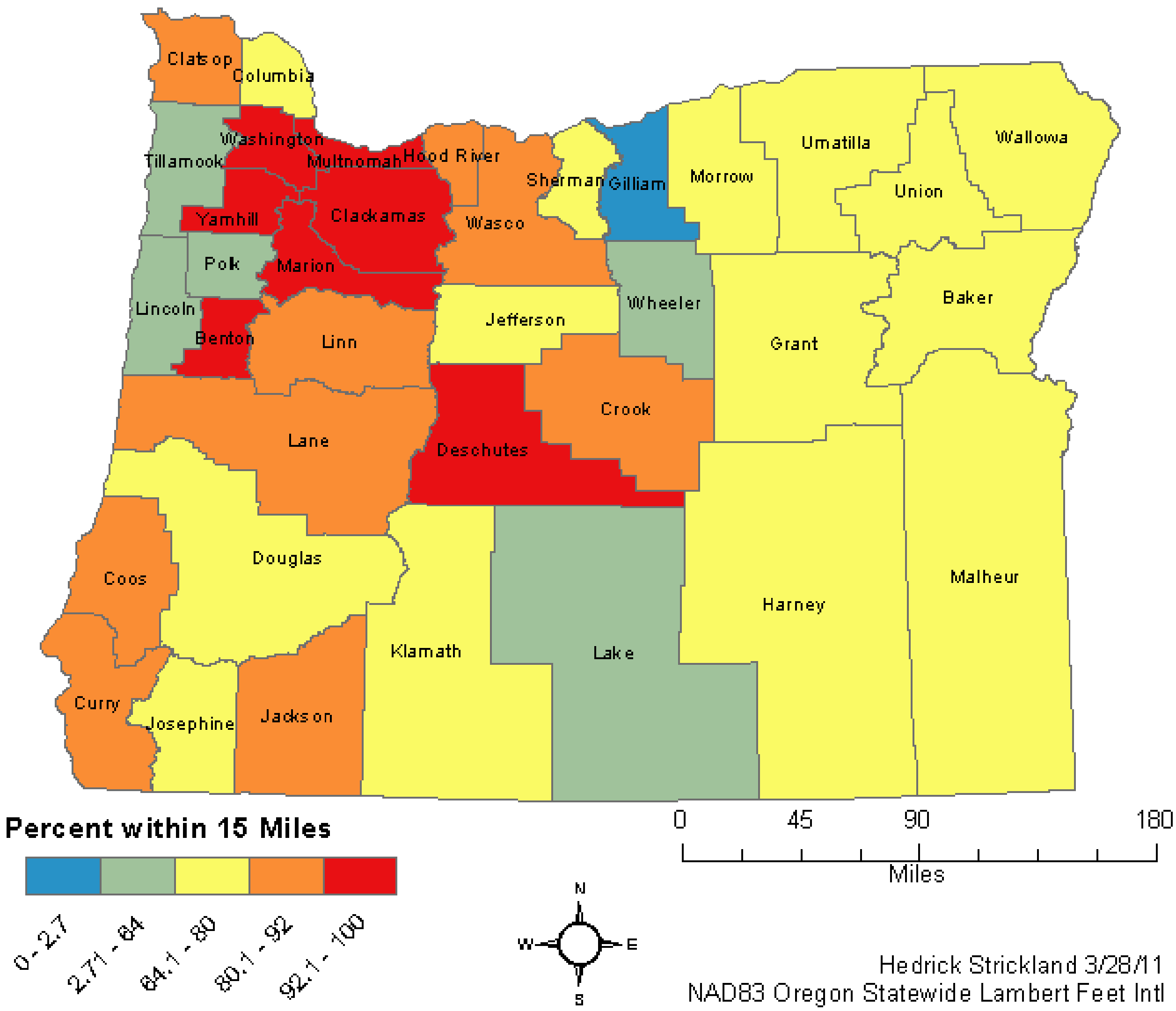

Figure 4: Percentage of Oregon residents, by county, within 15 miles of the nearest paint collection facility [17, 20].

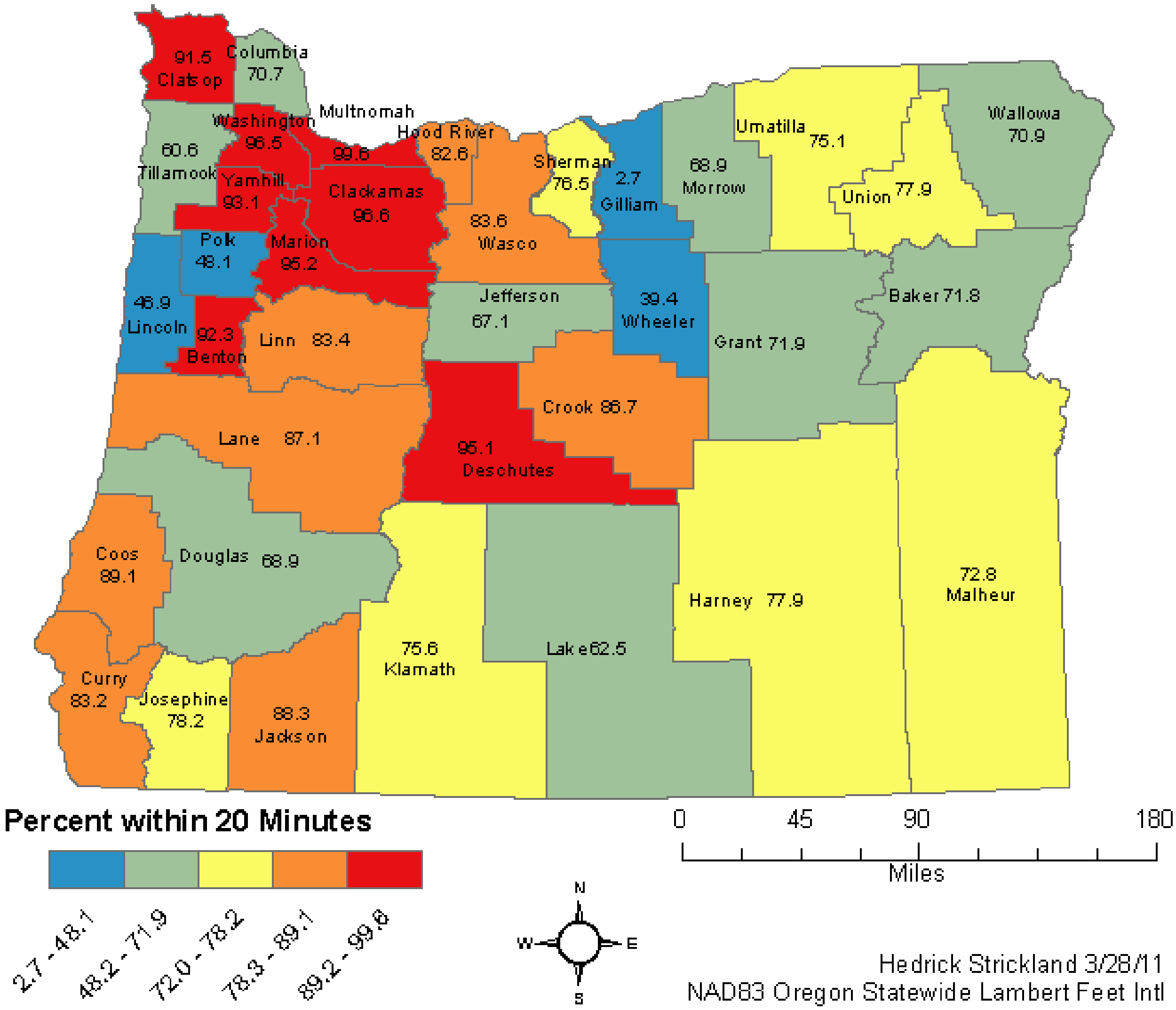

Figure 5: Percentage of Oregon residents, by county, within 20 minutes of the nearest paint collection facility [17, 20].

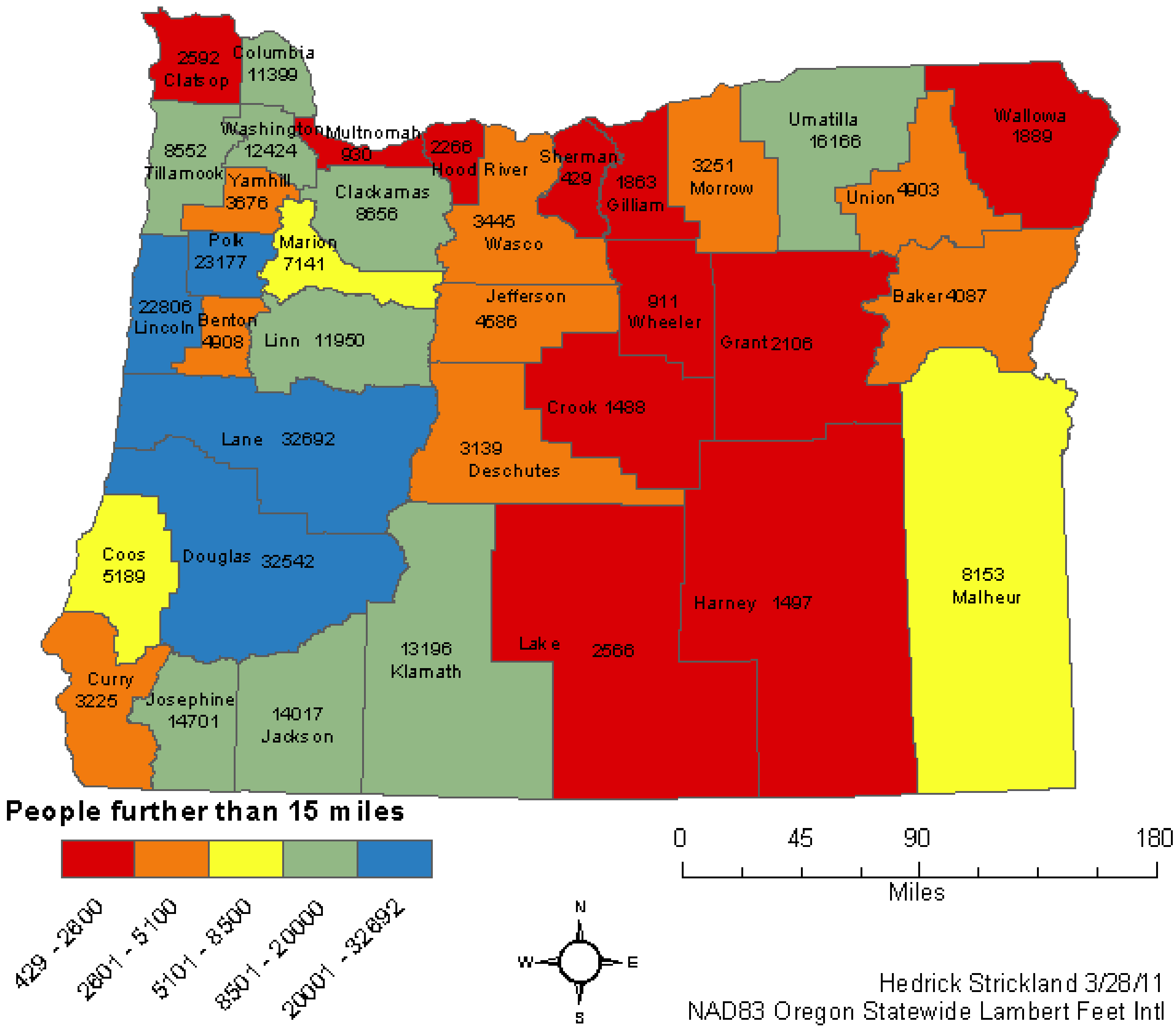

Figure 6: Estimated number of people in each county that are not within 15 miles of a collection facility [17, 20].

I have noted the inconsistency in access provided to residents of different counties. There is also inconsistency in the degree of access provided to urban residents versus suburban and rural residents. Only 4 of the sites active as of January 24, 2011 are located outside of a Census 2010 Urban Growth Area (UGA) [17]. Approximately 96% of urban residents, defined as those within a UGA, are within 15 miles of a collection facility. In contrast, only about 71% of residents outside of a UGA are within 15 miles of a collection facility. Figure 7 shows the location of 15 mile service areas in relation to Census 2010 Urban Growth Areas [17].

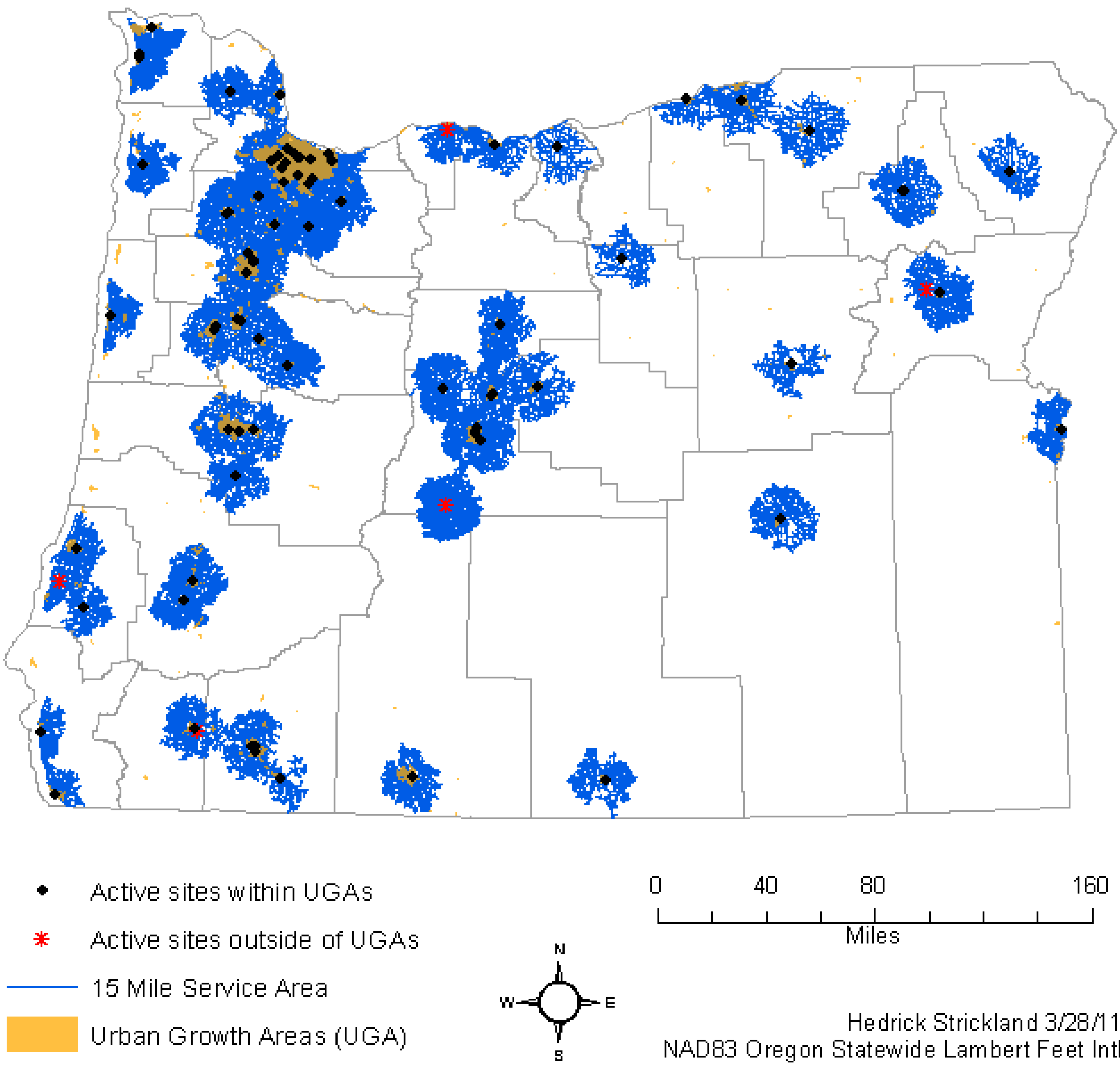

Figure 7: Display of the active collection facilities and service areas located within Census 2010 Urban Growth Areas (UGAs) [17].

Only four facilities, marked with a red asterisk are located outside of urban growth areas, shown in orange, and often hidden by the black point indicating the presence of a collection facility. Urban growth areas are generally small so the service areas usually extend outside of urban areas, into suburban and rural areas. About 96% of urban residents and 71% of rural and suburban residents, respectively, are within 15 miles of the nearest collection facility.

Discussion

Overall, the degree of access convenience, defined by the driving time and distance to the nearest collection facility and offered by the paint recycling program, is high. More than 90% of Oregon residents are within 15 miles or 20 minutes of a collection facility. An interesting point is that the difference between the percentage of the population within 20 minutes and 15 miles ranges 1-3 percentage points for most counties. Polk County however, has 63% of its residents within 15 miles of a collection facility but only 49% within 20 minutes. The difference here is greater than 14 percentage points, which could occur in areas where many roads have low speed limits.

One county in particular, Gilliam County, has the most limited access. While Gilliam County has fewer than 2000 people, fewer than 3% of them are within 15 miles or 20 minutes of a collection facility. It is vastly underserved relative to other counties. The next lowest, by contrast, is Wheeler County, with approximately 40% of the population within 15 miles and 20 minutes. One of the goals of the Oregon program was to provide convenient access to residents of less populous areas, not just residents in metropolitan areas. Therefore, a small yearly collection event in a central location of Gilliam County would help to provide paint recycling opportunities to members of this county.

Douglas, Polk, and Lincoln counties are among the highest ranked for the number of residents further than 15 miles from a collection facility, and these counties are also among the lowest ranked for percentage of the population within this 15 mile service area. Therefore, these counties are relatively underserved by both measures and may benefit from additional collection sites if funds or efforts become available. As of January 24, 2011 there were plans to activate 4 more sites in Lincoln County but there are not, to the best of my knowledge, any plans to add additional sites in the other two counties.

I performed a site selection analysis on Gilliam, Polk, and Douglas counties individually to estimate where a collection facility should be placed if funds became available. I specified a minimize impedance problem type and an unlimited service area. I used the census blocks for the county only, rather than statewide but I did include existing sites statewide. Therefore, selected sites take into consideration that close facilities may be located in adjacent counties. I used the center of each census block both as demand points and as potential facilities. Therefore the recommended "site" is actually the center of a census block. A suitable collection site (for example, a paint store) may or may not be in the selected census block or nearby. These sites are most likely in areas of high density so they will likely be in residential areas. Figure 8 shows the location of the selected sites, which are in pockets of high density, as expected. The sites in Gilliam, Polk, and Douglas counties are within census block numbers 410219601002228, 410530204002062, and 410190500024029 respectively.

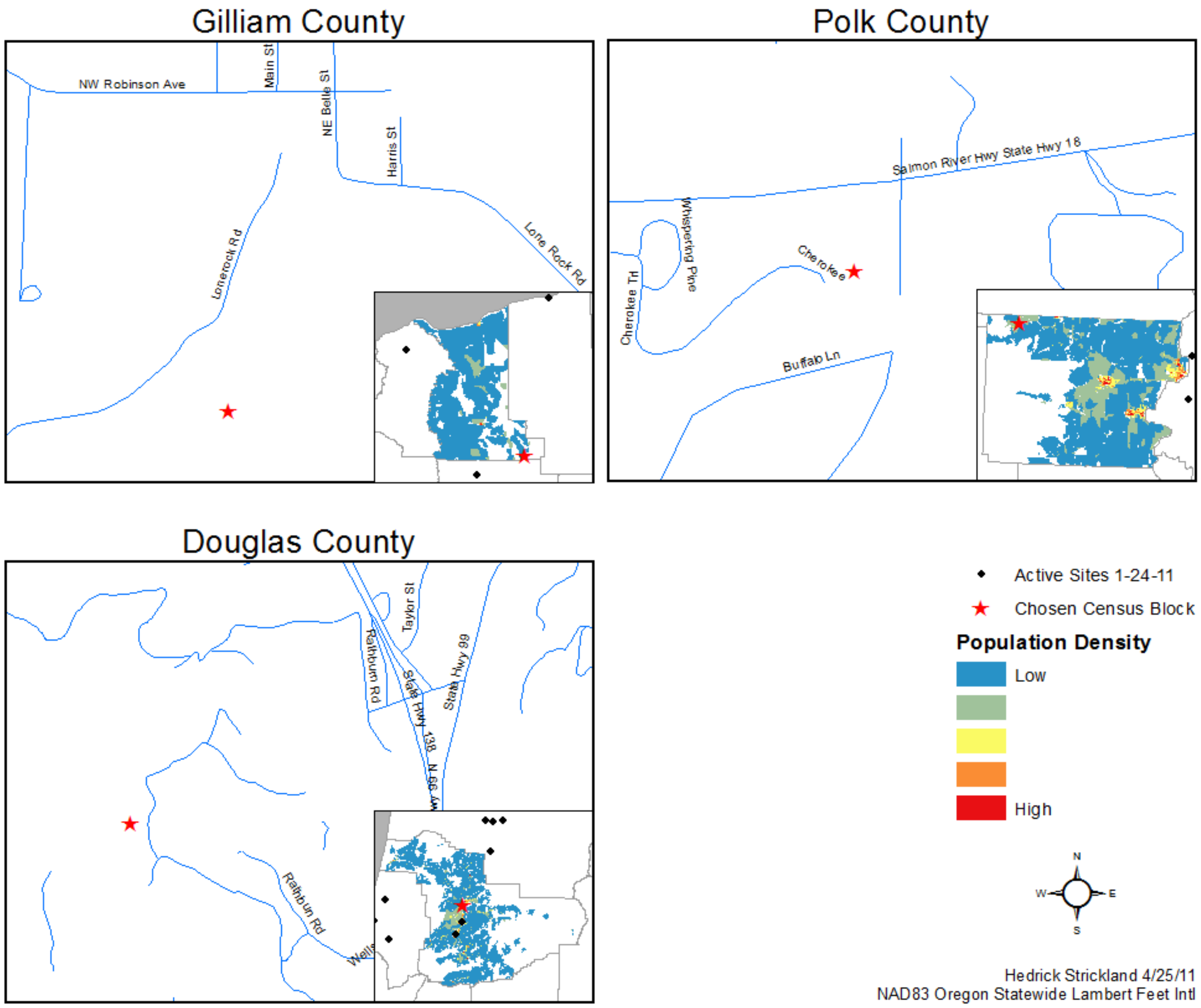

Figure 8: Best locations in Gilliam, Polk, and Douglas counties to site collection facilities if additional funds become available [17, 20].

I used the center of each census block both as demand points and as potential facilities. Therefore the recommended "site" is actually the center of a census block and a suitable collection site (for example, a paint store) may or may not be in that census block or nearby. The population density was included to highlight population centers but the scale varies for each county.

Site Selection and Convenience Analysis Tool

Methods

My Site Selection and Convenience Analysis tool is a decision support tool that draws upon the convenience analysis methods previously described to analyze the output from a location-allocation process. The location-allocation process is included in the

Network Analysis toolset and is a new addition to ArcGIS 10.0 [15]. It synthesizes the demand from the areas surrounding potential locations and chooses the locations, from a set of potential locations, which provide the best access to the areas of demand. The demand is represented in my analysis as the population of each census block clustered in the center of the block (Fig 9). Since location-allocation is a combination optimization process, the number of potential solutions can be vast. For example, an analysis set up to select the best 15 locations from a set of 30 locations would have more than 155 million possible solutions. Because, an exhaustive search is impractical, the location-allocation process utilizes heuristics to speed up the calculations and return a near-optimal solution. A full description of the location-allocation process is described in the ArcGIS Desktop 10 Help [22]. Chosen locations are added to the existing network of collection facilities and the degree of convenience offered by the combined existing and chosen collection facilities is determined at both the state and county level.

Figure 10 is a simplified version of the location-allocation process that I used in the tool. I removed the steps required to create demand points. Even a simple version is a 7-step process to get from specifying a location-allocation problem to saving a set of recommended sites, where each step is shown with a yellow box. Each input, shown by a white (optional input) or blue (required input) circle, in the column on the left is marked at the right hand corner with a "P." This indicates a user-specified input (model parameter), as opposed to the blue circle under the "add demand points" label, which is a permanent input that I, as the tool designer, specified. There are many inputs for each step of the process but I only allowed certain ones to be model parameters, those which may vary based on the specifics of the paint program being examined. An example of this would be the location of existing and potential facilities. Specifics of each model parameter are discussed in the results section. Using the tool I developed, users have to specify model parameters but they are able to bypass the process of performing the analysis step-by-step. For those needing more tool specifics, the python script is available in Appendix 1.

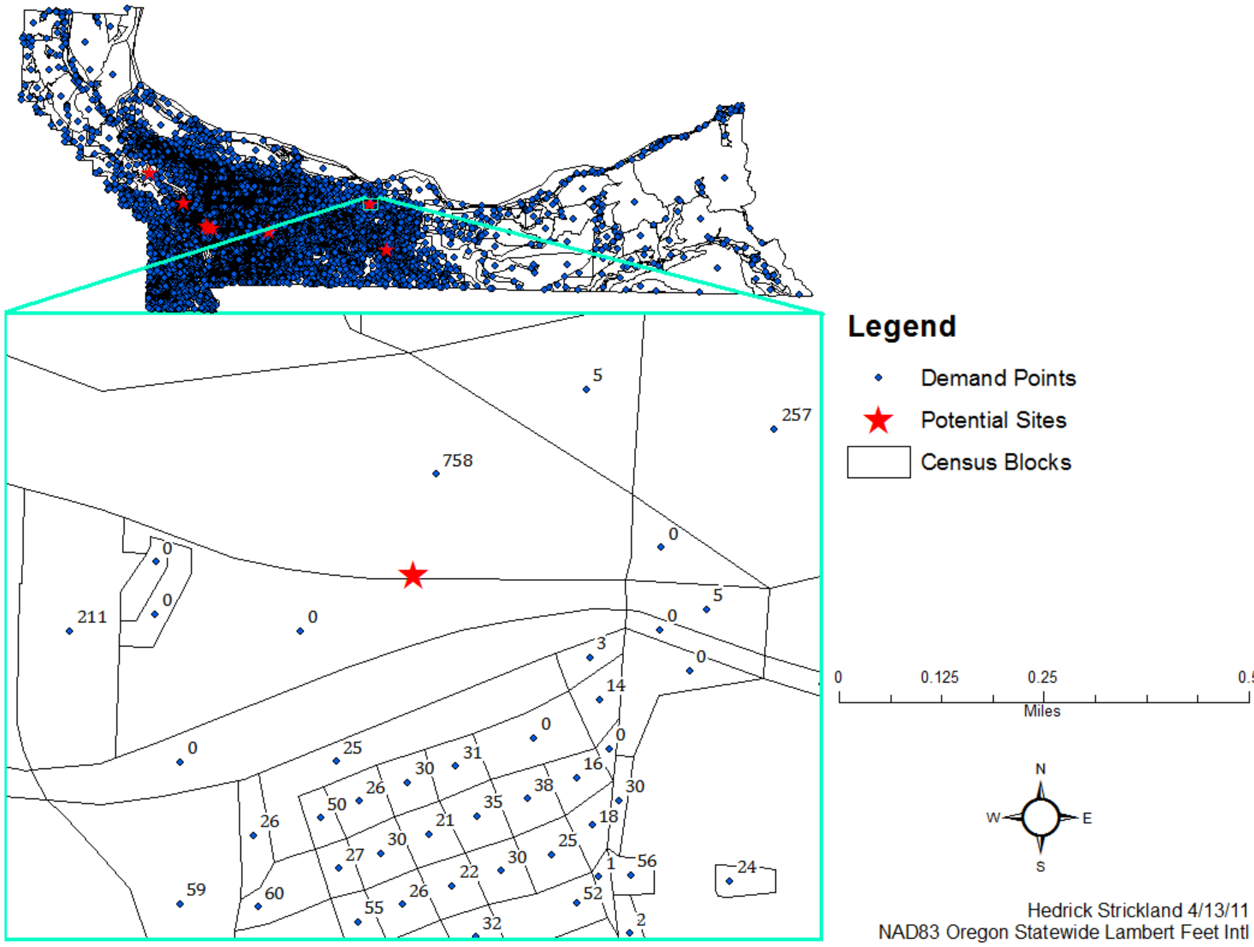

Figure 9: Potential facility in Multnomah County surrounded by demand points [20]. The Site Selection and Convenience Analysis tool selects potential facilities based on their proximity to demand points. Demand points represent people that may want to access a potential facility. They are designated in my analysis as the population of each census block clustered in the center of the block. Demand points, shown by blue dots, are labeled with the population of the census block that they represent.

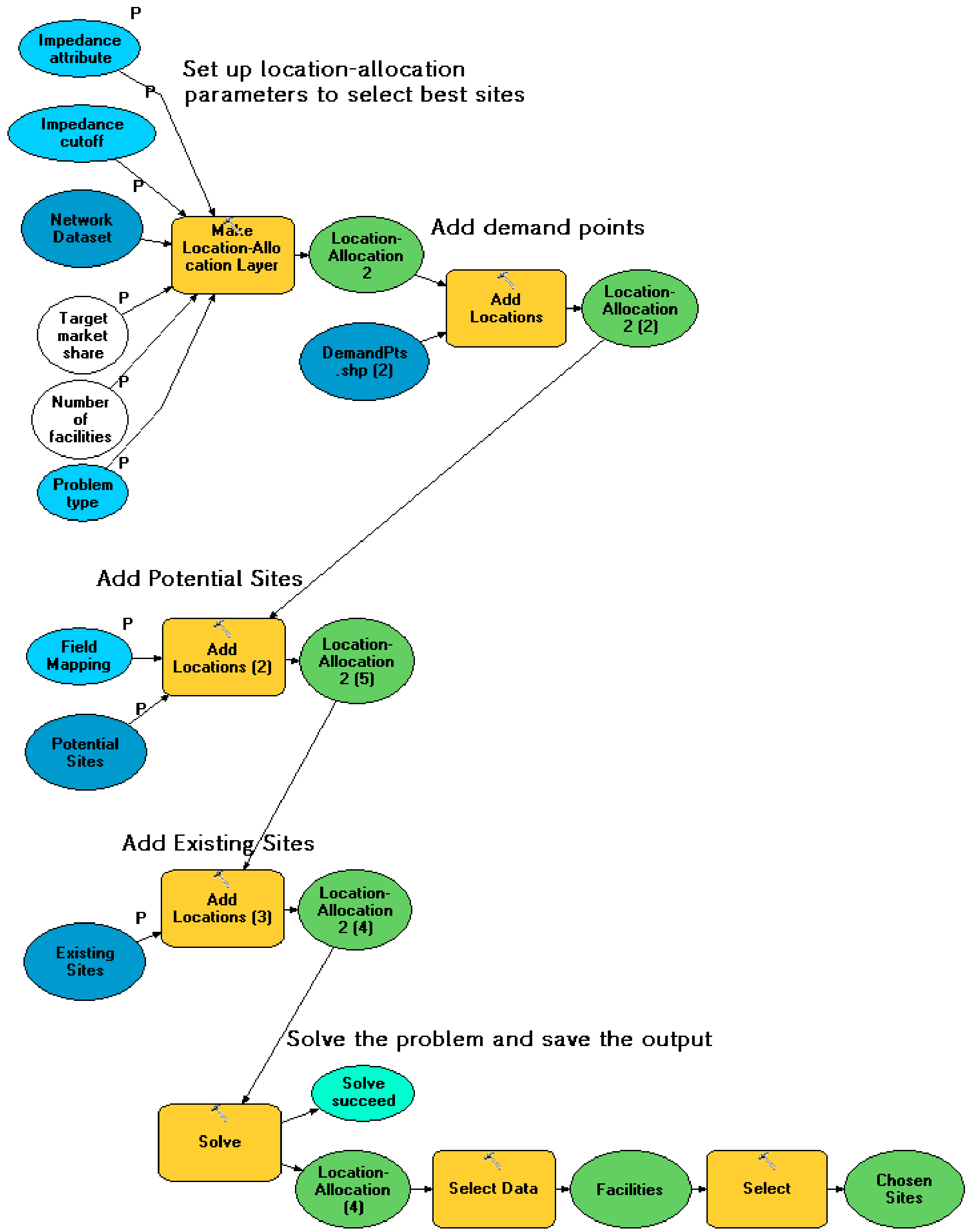

Figure 10: Simplified graphic of Location-Allocation process.
At its simplest, it is a 7-step process, where each step is shown with a yellow box. Each input, marked at the right hand corner with a "P," is a user-specified input (model parameter). There are many other inputs but I only allowed certain ones to be model parameters if it may vary based on the specifics of the paint program being examined. By developing a tool, users specify model parameters but they are able to bypass the process of performing the analysis step-by-step.

Results

This tool allows the user inputs described in Table 2, which are input through the user interface (Fig. 11). The output of the tool includes the identification of recommended site(s) and an estimate of the number of people that reside within each service area generated. The user may specify the output to be a single site, a specific number of sites, or however many sites are required to bring access to a given percentage of the population. Additionally, the tool generates summary tables that show the total percentage of the population within a given service area and the percentage of the population by county within the service area.

I ran the tool under 4 different scenarios to demonstrate how the tool works, how it can be used to fill in gaps in coverage, and how the choice of input data affects the results. Table 3 describes the tool demonstrations that I conducted. These demonstrations were performed using the active collection facilities in Oregon as potential sites, but they are purely for demonstration since the network of collection facilities in Oregon has already been established.

The first demonstration was to build from scratch a network of facilities to capture 80% of the population. I used census blocks, set a 15 mile service area, and left potential facilities un-weighted. Figure 12 shows the 19 facilities that were selected, shown by red stars.

Table 2: Inputs to Site Selection and Convenience Analysis tool with explanation and examples.

This tool selects, from a set of potential sites, the ones that serve the population most efficiently and then reports the percentage of the population that is within a given driving time or distance of the selected locations.

Inputs	Explanation	Examples
Roads Network	This allows service areas to be based on driving time or distance from a drop-off location, rather than straight line distance.	Census 2010 Roads
Problem Type	Minimize Impedance – Potential locations are selected such that the sum of all time or distance costs between demand points and solution locations is minimized. A user-defined number of facilities are selected. Maximize Coverage – Potential locations are located such that as many demand points as possible are within the cutoff time or distance of selected facilities. A user-defined number of facilities are selected. Minimize Facilities – The minimum number of locations are selected such that all demand points are included within the cutoff time or distance of a selected location; Demand points that are further than the cutoff time or distance from any facility are excluded. It is the same as Maximize Coverage except the number of sites to locate is determined by the tool, rather than input by the user. Target Market Share - Target Market Share chooses the minimum number of potential locations necessary to capture a user-specified percentage of the population.	
Impedance Attribute	This describes the cost, in units of distance or time, of being farther from collection facilities.	Miles-service areas will include all roads within a given number of miles Minutes- service areas will include all roads within a given number of minutes

Inputs	Explanation	Examples
Geographic Census Data	The population within each census unit is the source of both population estimates within each service area and estimates of demand. Blocks are the smallest unit, followed by block groups, and then tracts	Census 2000 blocks
Heading of Population Column	Enables the tool to accommodate Census 2010 population data when they become available	"[Pop2000]" is the column heading in Census 2000 data
Current Drop-off locations	These must be geocoded, spatially located based on a list of addresses.	Sites active by January 24, 2011
Potential Drop-off locations	These must be geocoded, spatially located based on a list of addresses.	Sites not yet active by January 24, 2011
Impedance Cutoff	This is the furthest distance or time that is considered part of a service area.	5, 10, and 15 Miles 5, 10, and 20 Minutes
Number of Facilities to Find (optional)	Required for Minimize Distance/Time and Maximize Coverage problems Optional for Target Market Share problems: the tool will only return this number of sites, even if the target market share was not met. Invalid for Minimize Facilities problems	E.g., "20", the tool will select the 20 best sites
Target Market Share (optional)	Required for Target Market Share problems Invalid for Minimize Distance/Time, Minimize Facilities, and Maximize Coverage problems	E.g.,"80," the tool will select the least number of sites that provide access to 80% of the demand
Facility Weights (optional)	Optional for Target Market Share problems Invalid for Minimize Distance/Time, Minimize Facilities, and Maximize Coverage problems A weight of 2 implies that a facility is twice as desirable as a facility with a weight of 1	Potential locations may be weighted based on criteria such as cost to operate or hours of operation.

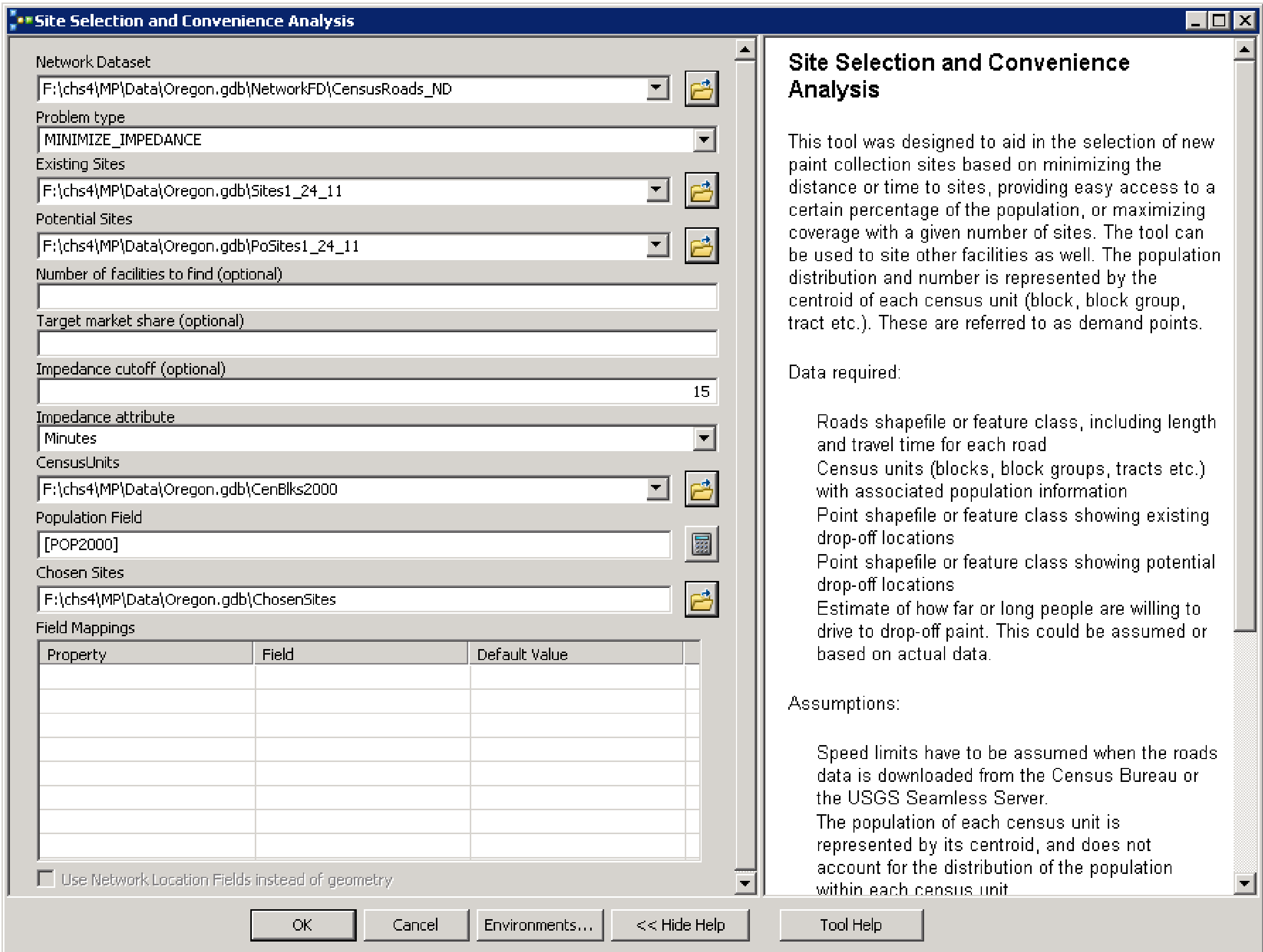

Figure 11: User interface for Site Selection and Convenience Analysis tool. The screenshot shows the user inputs area, along with a portion of the overview documentation for the tool. Additional information is available when a user clicks on each input field. The associated python script is available in Appendix 1.

Table 3: Demonstrations showing how the Site Selection and Convenience Analysis tool can be used to select collection facilities from a set of potential facilities.

Demonstration	Description
#1	80% target market share problem using census blocks and 15 mile service area, potential facilities unweighted, no pre-existing facilities (Figure 10)
#2	80% target market share problem using census blocks and 15 mile service area, potential facilities weighted by weekly hours of operation, no pre-existing facilities (Figure 10)
#3	80% target market share problem using census block groups and 15 mile service area, potential facilities unweighted, no pre-existing facilities (Figure 12)
#4	Minimize Impedance problem using census blocks and 15 mile service area, potential facilities unweighted, pre-existing facilities are those active January 24, 2011 (Figure 11)

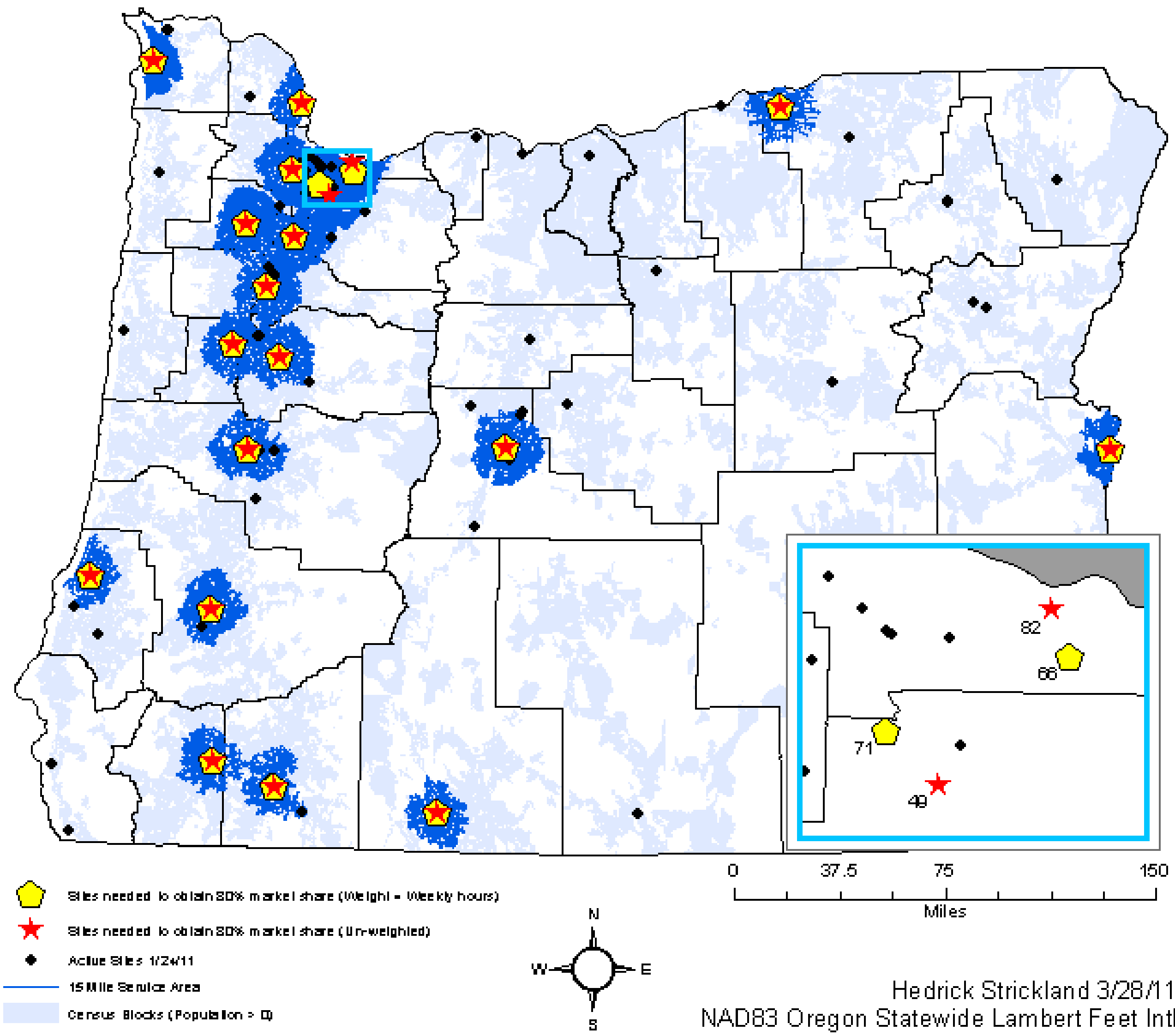

Figure 12: Minimum number and location of sites required to capture 80% of Oregon's population within 15 miles, when potential facilities are un-weighted and when potential facilities are weighted by their weekly hours of operation [17, 20]. In both cases, 19 facilities place 80% of the population within 15 miles of the closest collection facility. However, when I weighted potential facilities by their weekly hours of operation, two sites in Portland with a combined 131 weekly hours of operation (49 and 82 hours per week) were substituted for sites with a combined 137 weekly hours of operation (66 and 71 hours per week).

Individual preferences that affect consumer' perceptions of convenience, such as hours of operation, may be incorporated into the decision support tool by specifying different weights for each potential site under consideration. For example, a user may specify the weekly hours of operation as the weight so that when two locations provide service to a similar number of people, the one that is open the longest is chosen as the best site even though it may be a bit more remote. Potential sites could also be weighted based on the cost to start or operate each facility. A facility with a weight of 2 is preferred 2:1 over a facility with a weight of 1 [22]. Demonstration #2 was identical to demonstration #1, except potential locations were weighted to the weekly hours of operation. In this scenario as well, 19 facilities were selected but 2 sites selected in the first demonstration near Portland with 131 combined weekly hours of operation (49 and 82 hours per week) were substituted for 2 sites with 137 combined weekly hours of operation (66 and 71 hours per week) (Fig. 12).

The second part of the tool, which uses the same methods that I used to analyze the convenience offered by the active sites, determines the percentage of the population within the specified service area. In this case, the tool estimated that the 19 facilities selected during the first demonstration where potential facilities were un-weighted, captured 2,741,987 people or 80.1% of Oregon's population within 15 miles of the nearest selected collection facility. In this case, I knew the percent of the population within a 15 mile service area would be approximately 80% because I specified that percentage. However, the percentage is not known when the model is run with other problem types (minimize time/distance, maximize coverage, or minimize facilities). This is a testament to the accuracy of both the site selection portion of the tool and the subsequent convenience analysis methodology.

Demonstration #3 (Fig. 13) shows the minimum number and location of sites required to capture 80% of Oregon's population within 15 miles, when census block groups, rather than census blocks are used to define demand points. It is otherwise identical to demonstration #1. When blocks were used in demonstration #1, 19 facilities indicated by red stars were chosen. When block groups were used in demonstration #3, the distribution of selected locations was similar, indicated by yellow pentagons, but three facilities were substituted for nearby locations and a 2nd site in Umatilla County (highlighted) was added, bringing the total number of sites to 20, rather than 19.

Finally, demonstration #4 illustrates how the tool can be used to build upon an existing network of collection facilities, rather than starting one from scratch, as in the previous examples. In this scenario, there are 5 collection facilities that had not been activated as of January 24, 2011. I ran the tool using those 5 sites as potential sites, and specified that 3 of those sites should be chosen, as would be the case if, for example, funding were only available for 3 more active drop-off sites. The problem type was "minimize impedance" and the service area was set to 15 miles. Figure 14 indicates that two sites in Lincoln County (on the left in the figure) and one in Marion County best fill in the coverage gaps allowed by the existing network of collection facilities.

Like all network analyses, this tool requires significant data preparation including the following:

- Creation of a unified roads network. This can be quite lengthy if the study area involves analysis across multiple counties. Additionally, speed limits must be added and the time and distance that it takes to traverse each road segment must be calculated.

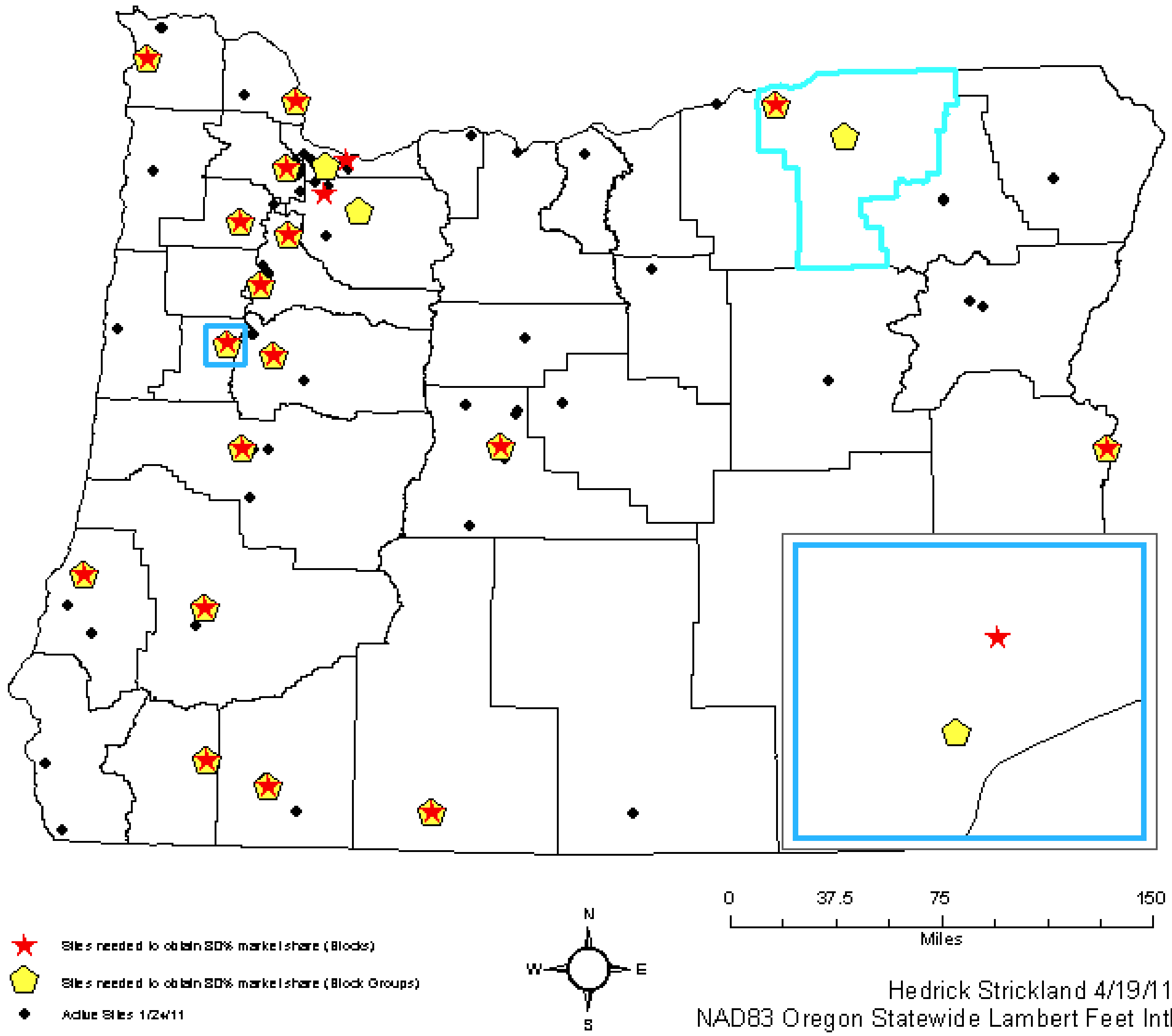

Figure 13: Minimum number and location of sites required to capture 80% of Oregon's population within 15 miles, using blocks versus block groups to define demand points [17, 20].

When blocks were used, 19 facilities, indicated by red stars, were chosen to place 80% of the population within 15 miles of the closest collection facility. When block groups were used, the distribution of selected locations was similar, indicated by yellow pentagons, but three facilities were substituted for nearby locations and a 2nd site in Umatilla County (highlighted) was added, making 20 sites total. The inset shows where there are two facilities located very close to one another. One was chosen in demonstration 1, while the other was chosen in demonstration 3.

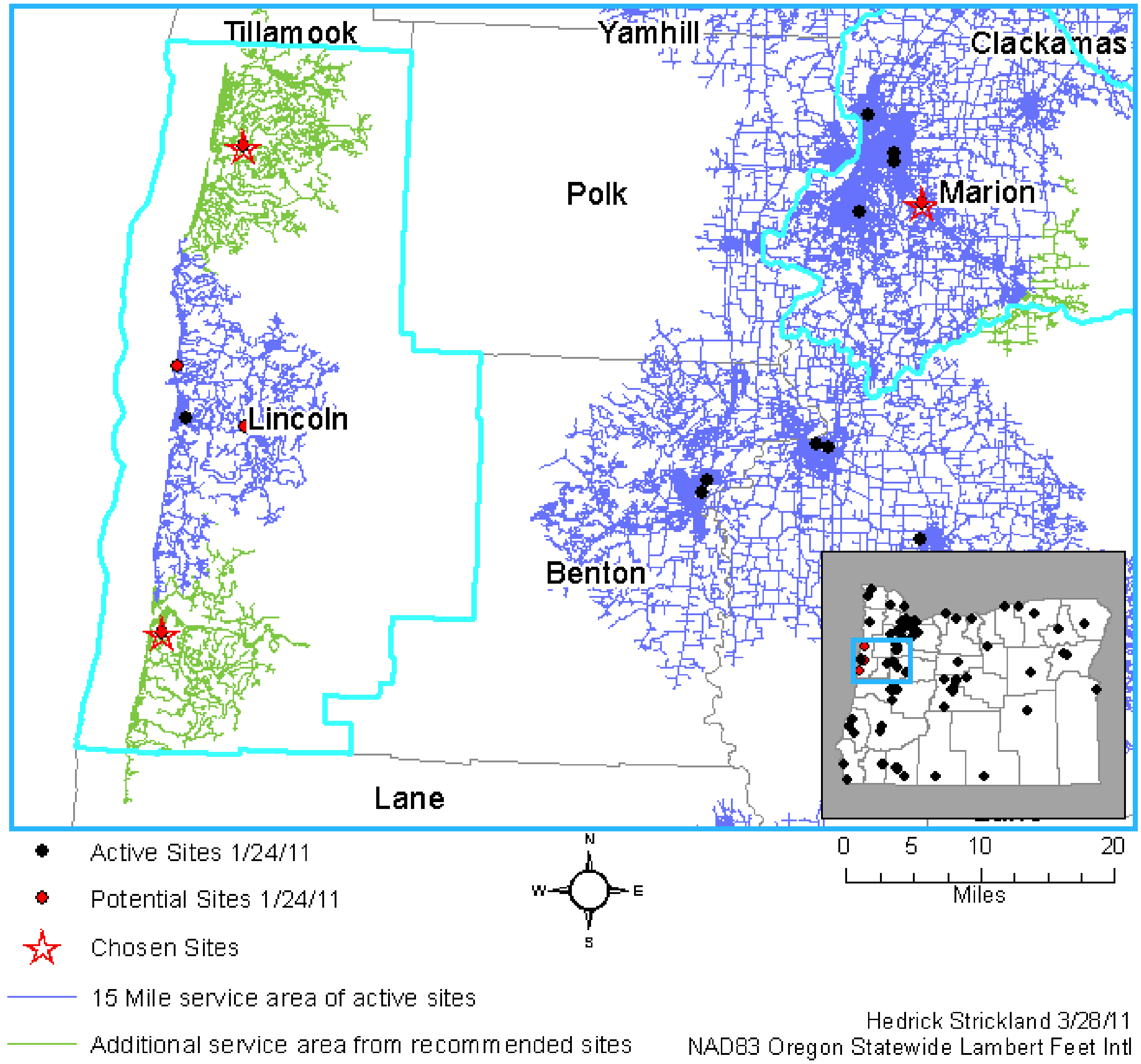

Figure 14: Three potential sites that best complement the network of drop-off facilities active in the Oregon paint management pilot program as of January 24, 2011 [17, 20].
Selected sites are in Lincoln and Marion counties (highlighted).

- Geographic census areas (census blocks, block groups, or tracts) must be downloaded, merged with other counties in the study area, and joined to demographic data.
- The locations of existing and potential drop-off sites must be geocoded, spatially located based on a list of addresses, and checked for accuracy.

Discussion

A number of different methods have been used to aid in the selection of potential sites for different purposes. Most of these are computationally intensive and require specialized experience. The Travel Cost Model, for example, was designed to recommend the site of recreation locations based on minimizing travel cost and resource inputs for recreators to potential and existing sites. This conventionally includes the cost of site operation, opportunity costs, and investment cost, in addition to the travel cost [23].

A second approach is the Spatial Recreation Allocation Model. Like the Travel Cost Model, this model considers a variety of factors when selecting the best sites, including the demand function for the existing sites, travel cost from demand points, the management and opportunity costs of sites, and site capacity. The following equation solves this model [23]:

Maximize

$$\sum_{j=1}^{J} \int_{0}^{E_j} D_j(E_j)\, dE_j - \sum_{j=1}^{J} \sum_{i=1}^{I} (T_{ij} + M_{ij} + C_{ij}) R_{ij},$$

subject to

$$\sum_{i=1}^{I} R_{ij} = E_j \qquad \forall\, j,$$

$$\sum_{j=1}^{J} R_{ij} \le A_i \qquad \forall\, i,$$

where,
i = index of existing and proposed sites
j = index of travel origins (demand points)
E_j = number of Recreation Visitor Days (RVDs) per year from origin j
D_j = first-stage demand function for the existing site and origin j
R_{ij} = the number of RVDs per year at site i from origin j
T_{ij} = the travel cost per R_{ij}
M_{ij} = the management cost per R_{ij}
C_{ij} = the opportunity cost per R_{ij}
A_j = the capacity in RVDs per year for site i
J = the number of origins
I = the number of sites (existing and proposed)

A number of other opaque and computationally nightmarish methods are available to solve location selection problems (see Lotto and Ferrara [24], Cooper [25], and Yao et al. [26]).

My GIS approach to solving location selection problems does not take into consideration any factors except for the time or distance between demand points and potential facilities, although facility weights can be adjusted to take into account other criteria deemed important by the user. While it may not be as comprehensive as other models used to solve location selection problems, my tool does offer a number of advantages. Most importantly, this type of network analysis is readily implemented using standard GIS software and does not require expertise beyond that found in government GIS departments [16]. It is user-friendly and can be extended to included a wide variety of demographic data available from the Census Bureau, including age, race, or income.

I had intended to use the decision support tool to recommend additional sites in Oregon but, as of January 24, 2011, all except 5 sites had already become active and the remaining sites were soon to follow. The Oregon paint recycling program was perhaps a unique case in that all potential sites were funded and became active within the first year of the program. However, as the recycling program expands, subsequent states may not have the funding to support activation of all potential sites. In this case, the decision support tool can enable planners to make more informed choices about which new drop-off facilities best complement the existing network of facilities based on selected convenience criteria, given a limited budget. For example, demonstration #4 shows how a certain number of facilities could be added based on the amount of money available in the budget. The addition of those three additional sites would add less than 1.5 percentage points (from 90.6% to 91.9%) to the statewide population within 15 miles of a facility, demonstrating how the more existing sites there are, the less helpful is the addition of new sites. This information can be used to determine when a study area has adequate coverage, making activation of additional sites not worth the effort or expense. In this case, there were 87 existing sites that captured quite a large percentage of the population already. The small amount of improvement offered by adding the 3 next best sites may lead planners to conclude that additional facilities are not worth the extra expense. Those kinds of decisions depend on whether providing access at the county level or at the state level is more important and would have to be made on a case-by-case basis.

On the county level, the increase in accessibility from one or two additional sites can be dramatic. The addition of the two sites in Lincoln County increases the percentage of the county population within 15 miles of a collection facility from 48% to 94% (21,120 to 41,463 people within 15 miles), while the additional site in Marion County only increases accessibility within the county from 97% to 98% (274,691 to 277,739 people within 15 miles).

The tool can also help prioritize the order the sites should become active in order to extend coverage to the maximum number of people as early as possible. For example, how many sites should be activated in the largest city before the entire population is better served by locating the next site in a less populated area? Selected sites may be chosen from scratch, i.e., by selecting the combination of potential sites that minimize access time or distance or maximize coverage when no other sites are active, or they may be added to an existing network of sites, i.e., to fill in gaps in coverage or access. In Oregon's situation, there was a high demand to host collection facilities and there were no reasons or criteria to reject sites, so all sites were activated. If a tool were available that had been agreed upon by stakeholders, site selection might have been more systematic, transparent, and subject to accountability [27].

The decision support tool is flexible enough to be applied to different states or regions and will allow different areas to analyze convenience and aid the selection of additional facility locations based on their own priorities, including distance or time to facilities, coverage area, and providing access to a threshold percentage of the population. Furthermore, the desirability of facilities may be weighted based on any criteria, including hours of operation, cost to operate, or proximity to larger population centers as a proxy for the ability to combine errands. The decision support tool will support census block, census tract, or any other scale of population data, but finer resolution population data will take longer to process. Likewise, running the decision support tool for counties individually will be significantly faster than doing so statewide. This does not, however, account for the fact that the closest facility may be located in an adjacent county unless roads and sites of adjacent counties are intentionally included.

Sources of Error

The distance-based service areas are not approximations. They are exactly as accurate as the Census data from which they were derived, with the exception that there is no distinction between bridges/regular intersections and one way/two way streets using census roads. It is possible to obtain datasets that model one way streets and bridges, although usually on a smaller scale than statewide. Conversely, the time-based service areas are approximations because the speed limits for each road are inferred. Likewise, time-based service areas do not account for the time spent at stop signals, traffic, or the time it takes to turn, all of which tend to overestimate the size of these service areas. Users could attempt to account for this error by reducing the estimate of speed limit by a given percentage but this is still an estimate with its own implicit error. Therefore, while the population estimate within time-based service areas may be more meaningful in determining whether people will make the effort to drive to a collection facility, population estimates within distance based service areas are more accurate.

It is important to remember that, while the total population within each census unit is known fairly accurately, the distribution is entirely unknown. The convenience analysis assumes that residents are spread evenly along roads, while the decision support tool assumes that residents are clumped together in the center of each census unit. Neither of these represents the true distribution of residents so there is error in determining the actual number of people that fall within each service area in the convenience analysis and the demand assumed for the site selection process. The site selection process includes the entire population of a census unit if the center of the census unit falls within the set time or distance cutoff, as is commonly done in GIS analyses that seek to relate polygon-based areas to linear networks. Therefore, the actual distance to some areas of the census unit will be underestimated and the actual distance to other areas will be overestimated [16].

Conversely, the convenience analysis counts a proportion of the people within each census unit, but the proportion is an estimate unless the entire census unit falls within the service area. Given these limitations, the best way to improve the accuracy of the convenience analysis and the tool is to use the smallest census unit possible. Using smaller census units will better estimate the distribution of the population and it will improve the accuracy of the recommended site selection, especially in situations where potential locations are very close to each other. In this case, the facilities are close together so the repercussions for selecting the "wrong" facility are likely minimal, but if such accuracy is desired, the finer resolution population data are needed to distinguish which portions of the population would be served by each potential site. When potential sites are further away from each other, it is clearer which people will be closest to which sites.

Users of the decision support tool will be able to input their own census data, so they should be aware of the tradeoff between the speed and accuracy of using a larger census unit. The largest census unit is the census tract. Oregon has 755 tracts, which are subdivided into 2490 block groups, and further subdivided into 156,232 blocks [20]. Each census unit has its own demand point and so analyses using 156,232 demand points take much longer to run than those using 2490 or 755 demand points. For example, demonstration #1 selected the minimum number of facilities required to capture 80% of Oregon residents within 15 miles, using census block population data. The entire tool, including site selection, service area generation, and population estimate took approximately 4.5 hours to complete. The same analysis run with census block group population data (demonstration #3) took just under 45 minutes to complete.

The difference in accuracy between these two demonstrations is apparent. Demonstration #3, based on block group data, required 20 sites to capture 80% of the population, whereas this could be done with 19 sites using block data. Furthermore, part 2 of the tool, the convenience analysis, estimated using block group data that 80.3% of Oregon's residents are within 15 miles of these 20 facilities. In order to compare the accuracy, I input these 20 sites into the convenience analysis portion of the tool and ran it again using block population data. Part 1, site selection was based on block group data, and part 2, convenience analysis, was based on the finer-grained block data. This estimation, using a mix of block and block group data, indicate that 81% of Oregon's residents are within 15 miles of these 20 facilities. Therefore, the use of coarser block group data for the convenience analysis underestimated the population within the 15 mile service area by .7% statewide. On the county level, the use of block group data underestimated the population within the service area an average of .8% and 1.4% when counties were removed that had no residents within the service area. The results by county are available in Table A3 in Appendix 2.

Drop-off facilities are generally located in high-density areas, with population density decreasing away from the facility. This explains why the population estimate within the service areas is likely underestimated; a trend which is exacerbated by the use of larger census units. Thus, the use of coarser population data can affect the selected locations and underestimate the population within a given service area of selected locations. I did not run the analysis at all with census tracts because the data is extremely coarse.

A final source of error is the age of the population data. The most recent census data (2000) are, literally, as old as possible. Census data are updated every 10 years. Census 2010 population data were due to states by April 1st, 2011, but they have not yet been made available to the public through the US Census Bureau's website.

Suggestions for Further Analysis

My analyses were based on the assumption that 15 miles is a reasonable distance to travel to access a collection facility. Additional research to determine whether this distance is ideal would allow the creation of service areas based on actual user behavior and would increase the accuracy of my findings. I have only examined proximity to overall population centers, but accessibility could be examined based on other demographics available from the Census Bureau, such as age, gender, or race. This may be useful, for example, to see if certain groups are more likely to be excluded or, perhaps, to only examine convenience for the age group most likely to use architectural paint (i.e., excluding children and the elderly). Finally, there are factors other than proximity to a collection facility, such as the ability to combine activities, which influence consumers' perceptions of convenience. It would be possible to weight potential facilities based on their proximity to retail centers as an attempt to quantify consumers' ability to combine activities. A more thorough analysis could take into account these and other measures of convenience, as well as curbside collection programs, which were omitted from this study due to insufficient data.

Conclusion

I have presented a method for quantifying access convenience, expressed by the driving time or distance it takes to reach the nearest paint collection facility. This work indicates that the Oregon paint collection program has been successful in providing convenient access to the vast majority of the state's residents, based on the assumption that 15 miles is a reasonable distance to travel to drop off leftover paint. Access is uneven at the county level, however. The most underserved residents include those living in Gilliam, Douglas, Polk, and Lincoln counties. Four additional sites are planned for Lincoln County but not for any of the other three counties. If additional funding becomes available, facilities or collection events should be established in Gilliam, Douglas, or Polk counties.

As the paint management program expands to other states, the Site Selection and Convenience Analysis tool provides empirical, objective evidence that will enable planners to choose sites that provide the best access to residents and to determine the degree of convenience that the chosen sites offer. The tool is user-friendly and adaptable to different states, allowing users to input their own census data, roads network, and current and potential collection facility locations. It is adaptable to different priorities, allowing users to weight potential facilities based on their desirability and to select one of four problem types, Minimize Impedance, Maximize Coverage, Minimize Facilities, or Target Market Share (Table 2). Finally, it is adaptable to different degrees of development, allowing users to build a network of collection facilities from scratch or to add on to an existing network. Consistent with the goal to provide visual information, the GIS based tool generates visual and usable information in a way that is easy to understand, conveys a great deal of information, and is easily dispensed to the public. To receive a copy of the Site Selection and Convenience Analysis tool, send a request to hedrick998@gmail.com.

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Appendix 1: Additional tables of county results

Table A1: Estimated percentage of people in each county that are within 20 minutes or 15 miles of a collection facility.

County	Population 2000	Percent within 20 Minutes	Percent within 15 Miles
Multnomah	659352	99.8%	99.9%
Washington	441412	97.3%	97.2%
Clackamas	336729	97.1%	97.4%
Marion	283310	95.7%	97.5%
Deschutes	114968	95.4%	97.3%
Yamhill	84267	93.9%	95.6%
Benton	77663	92.9%	93.7%
Clatsop	35427	92.0%	92.7%
Jackson	178550	89.7%	92.1%
Coos	62379	89.6%	91.7%
Lane	320359	87.8%	89.8%
Crook	19049	87.3%	92.2%
Wasco	23617	84.2%	85.4%
Linn	102169	84.2%	88.3%
Curry	21034	83.6%	84.7%
Hood River	20363	82.8%	88.9%
Josephine	74976	79.0%	80.4%
Harney	7512	78.9%	80.1%
Union	24365	78.4%	79.9%
Klamath	62671	76.9%	78.9%
Sherman	1934	76.5%	77.8%
Umatilla	70105	75.5%	76.9%
Baker	16314	73.7%	74.9%
Malheur	31435	73.2%	74.1%
Grant	7866	72.5%	73.2%
Wallowa	7110	72.1%	73.4%
Columbia	43060	71.5%	73.5%
Morrow	10872	69.7%	70.1%
Douglas	99600	69.4%	67.3%
Jefferson	18722	68.2%	75.5%
Lake	7325	63.3%	65.0%
Tillamook	23855	61.7%	64.2%
Polk	61912	48.5%	62.6%
Lincoln	44105	47.3%	48.3%
Wheeler	1542	39.5%	40.9%
Gilliam	1915	2.7%	2.7%

Table A2: Estimated number of people in each county that are not within 15 miles of a collection facility.

County	People Further than 15 Miles	County	People Further than 15 Miles
Lane	32692	Jefferson	4586
Douglas	32542	Baker	4087
Polk	23177	Yamhill	3676
Lincoln	22806	Wasco	3445
Umatilla	16166	Morrow	3251
Josephine	14701	Curry	3225
Jackson	14017	Deschutes	3139
Klamath	13196	Clatsop	2592
Washington	12424	Lake	2566
Linn	11950	Hood River	2266
Columbia	11399	Grant	2106
Clackamas	8656	Wallowa	1889
Tillamook	8552	Gilliam	1863
Malheur	8153	Harney	1497
Marion	7141	Crook	1488
Coos	5189	Multnomah	930
Benton	4908	Wheeler	911
Union	4903	Sherman	429

Table A3: Percent of residents of each county that are within 15 miles of a collection facility chosen in demonstration 3. I selected the facilities required to capture 80% of the population within 15 miles, using block groups as the population data. The percentage within 15 miles of locations was calculated once using block groups and once using blocks to demonstrate how the results vary based on the census units chosen. The calculation using blocks is more accurate.

County	Percent in 15 Miles (block groups)	Percent in 15 Miles (blocks)	Difference
Malheur	66.3%	73.6%	-7.3%
Clackamas	88.5%	91.9%	-3.5%
Deschutes	70.1%	72.8%	-2.7%
Yamhill	83.0%	85.6%	-2.6%
Douglas	56.8%	59.2%	-2.5%
Morrow	27.4%	29.8%	-2.4%
Clatsop	72.9%	75.0%	-2.2%
Umatilla	74.6%	76.5%	-1.8%
Josephine	78.0%	79.6%	-1.5%
Linn	74.9%	76.2%	-1.3%
Jackson	86.1%	87.2%	-1.1%
Columbia	63.8%	64.4%	-0.6%
Coos	63.3%	63.9%	-0.6%
Benton	92.7%	93.1%	-0.4%
Baker	0.0%	0.0%	0.0%
Curry	0.0%	0.0%	0.0%
Gilliam	0.0%	0.0%	0.0%
Grant	0.0%	0.0%	0.0%
Harney	0.0%	0.0%	0.0%
Hood River	0.0%	0.0%	0.0%
Jefferson	0.0%	0.0%	0.0%
Lake	0.0%	0.0%	0.0%
Lincoln	0.0%	0.0%	0.0%
Sherman	0.0%	0.0%	0.0%
Tillamook	0.0%	0.0%	0.0%
Union	0.0%	0.0%	0.0%
Wallowa	0.0%	0.0%	0.0%
Wasco	0.0%	0.0%	0.0%
Wheeler	0.0%	0.0%	0.0%
Marion	95.0%	94.9%	0.0%
Lane	80.4%	80.3%	0.1%
Multnomah	99.4%	99.2%	0.1%
Klamath	75.9%	75.6%	0.3%
Polk	61.5%	61.0%	0.5%
Washington	96.7%	96.0%	0.7%
Crook	0.9%	0.2%	0.7%

Appendix 2: Additional GIS information

All GIS data are in the NAD83 Oregon Statewide Lambert Feet International projection.

The network dataset properties

Name: AllRdsCen10Prj_ND
Type: Shapefile-Based Network Dataset

Sources:
  Edge Sources:
    AllRdsCen10Prj

Connectivity:
  Group 1:
    Edge Connectivity:
      AllRdsCen10Prj (Any Vertex)

Elevation Model: None

Attributes:
  Time:
    Usage Type: Cost
    Data Type: Double
    Units Type: Minutes
    Use by Default: False
    Source Attribute Evaluators:
      AllRdsCen10Prj (From-To): Field = [Time]
      AllRdsCen10Prj (To-From): Field = [Time]
    Default Attribute Evaluators:
      Default Edges: Constant = 0
      Default Junctions: Constant = 0
  Distance:
    Usage Type: Cost
    Data Type: Double
    Units Type: Miles
    Use by Default: True
    Source Attribute Evaluators:
      AllRdsCen10Prj (From-To): Field = [Dist]
      AllRdsCen10Prj (To-From): Field = [Dist]
    Default Attribute Evaluators:
      Default Edges: Constant = 0
      Default Junctions: Constant = 0

Directions:
  Directions Ready: No
    -Length Attribute Required
    -Street Name Field Required [AllRdsCen10Prj]

Python script for Decision Support Tool

```
# ---------------------------------------------------------------------------
# Script.py
# Created on: 2011-04-29 14:15:49.00000
#   (generated by ArcGIS/ModelBuilder)
# Usage: Script <Problem_type> <Network_Dataset> <Existing_Sites> <Potential_Sites>
<CensusUnits> <Number_of_facilities_to_find> <Target_market_share> <Field_Mappings>
<Impedance_cutoff> <Impedance_attribute> <Re-enter_Impedance_Attribute>
<Chosen_Sites> <AllCounties> <Population_Field> <Roads>
# Description:
# ---------------------------------------------------------------------------

# Set the necessary product code
# import arcinfo


# Import arcpy module
import arcpy

# Check out any necessary licenses
arcpy.CheckOutExtension("Network")

# Set Geoprocessing environments
arcpy.env.scratchWorkspace = "F:\\chs4\\Final\\Scratch"
arcpy.env.workspace = "F:\\chs4\\Final\\Data"

# Script arguments
Problem_type = arcpy.GetParameterAsText(0)
if Problem_type == '#' or not Problem_type:
    Problem_type = "MINIMIZE_IMPEDANCE" # provide a default value if unspecified

Network_Dataset = arcpy.GetParameterAsText(1)

Existing_Sites = arcpy.GetParameterAsText(2)

Potential_Sites = arcpy.GetParameterAsText(3)

CensusUnits = arcpy.GetParameterAsText(4)

Number_of_facilities_to_find = arcpy.GetParameterAsText(5)

Target_market_share = arcpy.GetParameterAsText(6)

Field_Mappings = arcpy.GetParameterAsText(7)
if Field_Mappings == '#' or not Field_Mappings:
    Field_Mappings = "Name Name #;FacilityType # 0;Weight # 1;CurbApproach # 0" #
provide a default value if unspecified
```

```
Impedance_cutoff = arcpy.GetParameterAsText(8)
if Impedance_cutoff == '#' or not Impedance_cutoff:
    Impedance_cutoff = "15" # provide a default value if unspecified

Impedance_attribute = arcpy.GetParameterAsText(9)

Re-enter_Impedance_Attribute = arcpy.GetParameterAsText(10)
if Re-enter_Impedance_Attribute == '#' or not Re-enter_Impedance_Attribute:
    Re-enter_Impedance_Attribute = "15" # provide a default value if unspecified

Chosen_Sites = arcpy.GetParameterAsText(11)
if Chosen_Sites == '#' or not Chosen_Sites:
    Chosen_Sites = "F:\\chs4\\Final\\FinalOutputs.gdb\\ChosenSites" # provide a default
value if unspecified

AllCounties = arcpy.GetParameterAsText(12)

Population_Field = arcpy.GetParameterAsText(13)
if Population_Field == '#' or not Population_Field:
    Population_Field = "Population Field" # provide a default value if unspecified

Roads = arcpy.GetParameterAsText(14)

# Local variables:
Location-Allocation_2 = Problem_type
Location-Allocation_2__3_ = Location-Allocation_2
Location-Allocation_2__5_ = Location-Allocation_2__3_
Location-Allocation_2__4_ = Location-Allocation_2__5_
Location-Allocation__4_ = Location-Allocation_2__4_
Facilities = Location-Allocation__4_
Solve_succeeded = Location-Allocation_2__4_
Service_Area = Solve_succeeded
Service_Area__3_ = Service_Area
Service_Area__2_ = Service_Area__3_
Lines = Service_Area__2_
Chosen_SitesSA = Lines
CenChosenSA_shp = Chosen_SitesSA
CenChosenSA_shp__2_ = CenChosenSA_shp
CenChosenSA_shp__3_ = CenChosenSA_shp__2_
CenChosenStat_dbf = CenChosenSA_shp__3_
ChosenSAStat_dbf__3_ = CenChosenStat_dbf
ChosenSAStat_dbf__4_ = ChosenSAStat_dbf__3_
ChosenSAStat_View = ChosenSAStat_dbf__4_
ChosenSAStat_dbf__5_ = ChosenSAStat_View
ChosenSAStat_View__2_ = ChosenSAStat_dbf__5_
ChosenSitesSum = ChosenSAStat_View__2_
ChosenSitesSum__2_ = ChosenSitesSum
ChosenSitesSum__3_ = ChosenSitesSum__2_
```

```
ChosenSitesCSum = ChosenSAStat_View__2_
ChosenSitesCSum__2_ = ChosenSitesCSum
ChosenSitesCSum__3_ = ChosenSitesCSum__2_
ChosenSitesCSum__4_ = ChosenSitesCSum__3_
Solve_succeeded__2_ = Service_Area__3_
CenUnits_Layer = CensusUnits
CenNoZero_shp = CenUnits_Layer
CenNoZero_shp__2_ = CenNoZero_shp
CenNoZero_shp__3_ = CenNoZero_shp__2_
DemandPts_shp = CenNoZero_shp__3_
ChosenSAStat_dbf = CenNoZero_shp__2_
ChosenSAStat_dbf__2_ = ChosenSAStat_dbf
BlksRds_shp = CenNoZero_shp__2_
BlksRds_shp__2_ = BlksRds_shp
BlksRds_shp__3_ = BlksRds_shp__2_
BlkRdsStat_dbf = BlksRds_shp__3_

# Process: Make Feature Layer (2)
arcpy.MakeFeatureLayer_management(CensusUnits, CenUnits_Layer, "\"POP2000\" > 0",
"", "OBJECTID OBJECTID VISIBLE NONE;Shape Shape VISIBLE NONE;ID ID VISIBLE
NONE;FIPSSTCO FIPSSTCO VISIBLE NONE;TRACT2000 TRACT2000 VISIBLE
NONE;BLOCK2000 BLOCK2000 VISIBLE NONE;STFID STFID VISIBLE
NONE;Shape_Leng Shape_Leng VISIBLE NONE;OBJECTID_1 OBJECTID_1 VISIBLE
NONE;STATE STATE VISIBLE NONE;COUNTY COUNTY VISIBLE NONE;TRACT
TRACT VISIBLE NONE;BLOCK BLOCK VISIBLE NONE;STFID_1 STFID_1 VISIBLE
NONE;POP2000 POP2000 VISIBLE NONE;URBAN URBAN VISIBLE NONE;RURAL
RURAL VISIBLE NONE;Shape_Le_1 Shape_Le_1 VISIBLE NONE;Shape_Length
Shape_Length VISIBLE NONE;Shape_Area Shape_Area VISIBLE NONE")

# Process: Copy Features (2)
arcpy.CopyFeatures_management(CenUnits_Layer, CenNoZero_shp, "", "0", "0", "0")

# Process: Add Field (7)
arcpy.AddField_management(CenNoZero_shp, "PopNew", "SHORT", "", "", "", "",
"NON_NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field
arcpy.CalculateField_management(CenNoZero_shp__2_, "PopNew", Population_Field, "VB",
"")

# Process: Make Location-Allocation Layer (2)
arcpy.MakeLocationAllocationLayer_na(Network_Dataset, "Location-Allocation 2",
Impedance_attribute, "DEMAND_TO_FACILITY", Problem_type,
Number_of_facilities_to_find, Impedance_cutoff, "LINEAR", "1", Target_market_share, "",
"ALLOW_UTURNS", "", "NO_HIERARCHY", "STRAIGHT_LINES")

# Process: Feature To Point
arcpy.FeatureToPoint_management(CenNoZero_shp__3_, DemandPts_shp, "INSIDE")
```

```
# Process: Add Locations
arcpy.AddLocations_na(Location-Allocation_2, "Demand Points", DemandPts_shp, "Name # #;Weight Population 1;GroupName # #;ImpedanceTransformation # #;ImpedanceParameter # #;CurbApproach # 0;Cutoff_Minutes # #;Cutoff_Distance # #;Cutoff_Miles # #", "5000 Meters", "", "AllRoads SHAPE;CensusRoads_ND_Junctions NONE", "MATCH_TO_CLOSEST", "APPEND", "NO_SNAP", "5 Meters", "INCLUDE", "AllRoads #;CensusRoads_ND_Junctions #")

# Process: Add Locations (2)
arcpy.AddLocations_na(Location-Allocation_2__3_, "Facilities", Potential_Sites, Field_Mappings, "5000 Meters", "", "AllRoads SHAPE;CensusRoads_ND_Junctions NONE", "MATCH_TO_CLOSEST", "APPEND", "NO_SNAP", "5 Meters", "INCLUDE", "AllRoads #;CensusRoads_ND_Junctions #")

# Process: Add Locations (3)
arcpy.AddLocations_na(Location-Allocation_2__5_, "Facilities", Existing_Sites, "Name Name #;FacilityType # 1;Weight # 1;CurbApproach # 0", "5000 Meters", "", "AllRoads SHAPE;CensusRoads_ND_Junctions NONE", "MATCH_TO_CLOSEST", "APPEND", "NO_SNAP", "5 Meters", "INCLUDE", "AllRoads #;CensusRoads_ND_Junctions #")

# Process: Solve
arcpy.Solve_na(Location-Allocation_2__4_, "SKIP", "TERMINATE")

# Process: Make Service Area Layer
arcpy.MakeServiceAreaLayer_na(Network_Dataset, "Service Area", Impedance_attribute, "TRAVEL_TO", Re-enter_Impedance_Attribute, "NO_POLYS", "MERGE", "RINGS", "TRUE_LINES", "NON_OVERLAP", "SPLIT", "", "", "ALLOW_UTURNS", "", "TRIM_POLYS", "0.1 Miles", "NO_LINES_SOURCE_FIELDS")

# Process: Select Data
arcpy.SelectData_management(Location-Allocation__4_, "Facilities")

# Process: Select
arcpy.Select_analysis(Facilities, Chosen_Sites, "\"FacilityType\" = 1 OR \"FacilityType\" = 3")

# Process: Add Locations (4)
arcpy.AddLocations_na(Service_Area, "Facilities", Chosen_Sites, "Name Name #;CurbApproach # 0;Attr_Miles # 0;Attr_Minutes # 0;Breaks_Miles # #;Breaks_Minutes # #", "1 Miles", "", "AllRoads SHAPE;CensusRoads_ND_Junctions NONE", "MATCH_TO_CLOSEST", "APPEND", "NO_SNAP", "5 Meters", "INCLUDE", "AllRoads #;CensusRoads_ND_Junctions #")

# Process: Solve (2)
arcpy.Solve_na(Service_Area__3_, "HALT", "TERMINATE")

# Process: Summary Statistics (5)
```

```
arcpy.Statistics_analysis(CenNoZero_shp__2_, ChosenSAStat_dbf, "PopNew FIRST",
"STFID;FIPSSTCO")

# Process: Intersect
arcpy.Intersect_analysis("# #;F:\\chs4\\Final\\Scratch\\CenNoZero.shp #", BlksRds_shp,
"ALL", "", "INPUT")

# Process: Add Field (4)
arcpy.AddField_management(BlksRds_shp, "RdLeng", "DOUBLE", "", "", "", "",
"NON_NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field (5)
arcpy.CalculateField_management(BlksRds_shp__2_, "RdLeng", "!shape.length!",
"PYTHON_9.3", "")

# Process: Summary Statistics (2)
arcpy.Statistics_analysis(BlksRds_shp__3_, BlkRdsStat_dbf, "RdLeng SUM", "STFID")

# Process: Join Field
arcpy.JoinField_management(ChosenSAStat_dbf, "STFID", BlkRdsStat_dbf, "STFID",
"SUM_RdLeng")

# Process: Select Data (2)
arcpy.SelectData_management(Service_Area__2_, "Lines")

# Process: Copy Features (3)
arcpy.CopyFeatures_management(Lines, Chosen_SitesSA, "", "0", "0", "0")

# Process: Intersect (2)
arcpy.Intersect_analysis("F:\\chs4\\Final\\FinalOutputs.gdb\\ChosenSitesSA
#;F:\\chs4\\Final\\Scratch\\CenNoZero.shp #", CenChosenSA_shp, "ALL", "", "INPUT")

# Process: Add Field (5)
arcpy.AddField_management(CenChosenSA_shp, "LineLeng", "DOUBLE", "", "", "", "",
"NON_NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field (2)
arcpy.CalculateField_management(CenChosenSA_shp__2_, "LineLeng", "!shape.length!",
"PYTHON_9.3", "")

# Process: Summary Statistics (6)
arcpy.Statistics_analysis(CenChosenSA_shp__3_, CenChosenStat_dbf, "LineLeng SUM",
"STFID")

# Process: Join Field (3)
arcpy.JoinField_management(ChosenSAStat_dbf__2_, "STFID", CenChosenStat_dbf,
"STFID", "SUM_LineLe")
```

```
# Process: Add Field (2)
arcpy.AddField_management(ChosenSAStat_dbf__3_, "AffPop", "SHORT", "", "", "", "",
"NON_NULLABLE", "NON_REQUIRED", "")

# Process: Make Table View
arcpy.MakeTableView_management(ChosenSAStat_dbf__4_, ChosenSAStat_View,
"\"SUM_RdLeng\" > 0", "", "STFID STFID VISIBLE NONE;FIPSSTCO FIPSSTCO
VISIBLE NONE;FREQUENCY FREQUENCY VISIBLE NONE;FIRST_PopN
FIRST_PopN VISIBLE NONE;SUM_RdLeng SUM_RdLeng VISIBLE NONE;SUM_LineLe
SUM_LineLe VISIBLE NONE;AffPop AffPop VISIBLE NONE")

# Process: Calculate Field (3)
arcpy.CalculateField_management(ChosenSAStat_View, "AffPop", "[SUM_LineLe] /
[SUM_RdLeng] * [FIRST_PopN]", "VB", "")

# Process: Select Layer By Attribute
arcpy.SelectLayerByAttribute_management(ChosenSAStat_dbf__5_, "CLEAR_SELECTION",
"")

# Process: Summary Statistics (3)
arcpy.Statistics_analysis(ChosenSAStat_View__2_, ChosenSitesSum, "AffPop
SUM;FIRST_PopN SUM", "")

# Process: Add Field (3)
arcpy.AddField_management(ChosenSitesSum, "PercentAff", "DOUBLE", "", "", "", "",
"NON_NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field (4)
arcpy.CalculateField_management(ChosenSitesSum__2_, "PercentAff", "[SUM_AffPop] /
[SUM_FIRST_PopN] * 100", "VB", "")

# Process: Summary Statistics (4)
arcpy.Statistics_analysis(ChosenSAStat_View__2_, ChosenSitesCSum, "AffPop
SUM;FIRST_PopN SUM", "FIPSSTCO")

# Process: Add Field (6)
arcpy.AddField_management(ChosenSitesCSum, "PercentAff", "DOUBLE", "", "", "", "",
"NON_NULLABLE", "NON_REQUIRED", "")

# Process: Calculate Field (6)
arcpy.CalculateField_management(ChosenSitesCSum__2_, "PercentAff", "[SUM_AffPop] /
[SUM_FIRST_PopN] * 100", "VB", "")

# Process: Join Field (2)
arcpy.JoinField_management(ChosenSitesCSum__3_, "FIPSSTCO", AllCounties,
"FIPSSTCO", "COUNTY")
```