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Retail Store Allocation

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CALCULATIONS

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Executive Summary

This report describes methods for deciding how many I-502 stores to license in each county in the State. Five "mathematical" methods are provided:

1. Prorate by population
2. Prorate by number of past-month users
3. Scale to linear sum of number of users and area
4. Scale to linear sum of number of users and square root of area
5. Minimize a proxy for average distance from a user to the closest store

Area – or more specifically the square root of area – relates to travel distances between points within a county.

In the associated spreadsheet, the first four allocation methods update automatically as the target number of stores for the state is adjusted; the last is more complex and requires some additional calculations (described in the accompanying user guide). We have pre-computed the distance-minimizing allocation for 100 to 1100 stores in increments of 50, demonstrating how average distance to the closest store falls from a little over 9 miles to a little over 2 miles as the number of stores increase. Even with just 200 stores, we'd expect users, on average, to have to travel not much more than six miles to their closest store.

The number of past-month users by county is an important input to this work. Those figures will come from Task 430-Rd, and we use preliminary values here to illustrate the five methods. The approach taken is to spread regional prevalence estimates provided by the National Survey on Drug Use and Health across counties in ways that reflect county-level treatment admissions, healthy youth survey data, and census data on total population and the number of young adults in each county. A more thorough explanation will be found in that task report.

We anticipate that the five methods' allocations will be starting points, which the LCB can manually adjust to consider idiosyncratic factors beyond the scope of these mathematical methods. We provide several tools to support that manual adjustment process, including comparisons with the allocation of liquor stores in 2012 and number of marijuana access points today, a color-coded table highlighting how the methods' allocations differ for each county, and automatically-updating scatter plots showing any instances of counties with similar population and area being allocated different numbers of stores.

We illustrate the methods and tools for two particular target numbers of stores statewide: 200 and 330, but we do not necessarily endorse either as the "correct" number.

There are many uncertainties concerning how many stores should be licensed, perhaps the biggest being how much market share I-502 stores can take away from the medical access points and the purely illegal black market. This suggest that some sort of

staged strategy, starting with a relatively limited number of stores and expanding as demand justifies may have appeal.

Introduction

This document and associated Excel workbook are intended to help LCB decide how many I-502 stores to license in total and in each county. This is viewed as an "allocation task". LCB first decides how many retail stores there should be in the state – a "budget" if you will. Then it will spread the stores around the counties in a fair and sensible manner.[1]

We present here a range of allocation strategies running from the very simple (prorating in proportion to county population) to ones that are more complicated (attempting to minimize the total travel distance from customers to the closest store). The various methods are all in broad agreement although of course do not lead to identical allocations.

It is anticipated that the total number of stores may be adjusted over time. Adjustments can be warranted by the refinement of information concerning certain parameters (such as the total quantity of marijuana consumed in Washington and what is a reasonable average annual sales volume for an I-502 store) and also as the I-502 stores take market share away from the medical and purely illicit markets.

We illustrate the various allocation rules for two cases: 330 and 200 stores statewide. We focus on 330 because it was used in the June 13th briefing, may be a reasonable target once the I-502 market has grown to serve roughly one-quarter of marijuana consumption in Washington, and is close to the number of LCB liquor stores in service during their last full year of operation. Two hundred stores pertains to another scenario outlined below, based on slightly different assumptions. However, the allocation procedure described below can be replicated to produce a different distribution of stores when and if the LCB is interested in investigating other "budgets" for the total number of stores in the state.

Determining the Total Number of Stores in the State

The statewide total number of stores could be determined in various ways. The spreadsheet is modular, so the calculation or entry of the total number of stores occurs on a separate sheet from the allocation steps; improving the flexibility of the spreadsheet.[2] One

[1] One could instead build up from the bottom by determining how many stores each county needs in order to achieve certain performance measures, such as making sure there is at least one store for every so and so many past-month users who live in the county. The "allocation" strategy is probably preferred, though, for two reasons. First, an "allocation" tool can essentially do the build-up task by being employed recursively. One would just allocate a certain number. If that left some counties falling short of the performance target (too few stores per user) then one would just crank up the total number of stores in the state and re-run the allocation. If the allocation model is working properly, it would never "short" a county badly if there were "extra" stores elsewhere in the state. Second, it is not at all clear how to decide on a performance metric for a build-up from the bottom strategy.

[2] For most of the allocation rules the number of stores by county updates automatically; for the travel-distance-minimizing some additional computation is required.

option would be simply to provide the same number of I-502 stores as former LCB liquor stores (332 in 2012, counting owned and contracted).

Another approach, which we have implemented, is determining the total number of stores by estimating the statewide I-502 sales and dividing by the desired average annual revenue per store. Total sales will equal current consumption (from the RAND analysis for Task 430-Rb) times price per gram (from Tasks 430-8(a) and 430-8(b)) and a guess of the market share of I-502 stores. Since that is unknown, the spreadsheet is designed to let LCB adjust that figure; one would expect market share to remain small during the first year or two and then grow over time.

The desired average store size (annual revenues) is a choice variable – subject to the constraint that it be above the minimum viable store size, or, more accurately, that it be some multiple above it, since some stores will be larger and some will be smaller than the average. The minimum viable store size in turn can be informed by the average size of a medical access point in Washington today (a side calculation suggests that may be $630K per year)[3] and/or Task 430-5(b)'s projection of I-502 compliant businesses operating costs and profits.[4]

A screenshot of that worksheet with parameter values that were used for the June 13th demo for WA-LCB is as follows.[5]

This front sheet computes the # of stores needed in the state in total.	
That # (computed in Cell C8) is passed as an input to the other sheets.	
(Yellow cells are parameters that can be changed freely.)	
165	Total quantity consumed in state (MT)
25%	Market share of 502 market
$12	Revenue per gram (total, including all taxes)
$ 495	Total sales, for all stores ($M)
$ 1.50	Target average operating scale per store ($M)
330	Target number of stores (sent to other sheets in the workbook)

All of these parameters are uncertain. For example, as of June 13th, a 90% confidence interval on the total market size might be approximately 120 – 220 MT. However, the market share parameter (set here at 25%) is perhaps the most uncertain; we

[3] See Task 430-8(b), Section 4(c)

[4] Currently, Luigi Zamarra projects the minimum viable store to require $1,500,000 in annual revenue before taxes to provide the entrepreneur with income of $80-$85K per year (personal communication, June 19th, 2013).

[5] Note the estimate of 165 MT per year starts with NSDUH data but adjusts for under-reporting, trends in marijuana use since the last year of the survey, and evidence about grams consumed per day. Later we use NSDUH prevalence estimates directly, without such an adjustment, when allocating stores to counties. The logic for that is that we have no data to indicate that under-reporting is any more or less severe in one part of the state relative to another, and the store allocation ultimately depends only on relative, not absolute, numbers of users.

think 25% is perhaps more plausible for the 2nd full year of operation (FY 2016) than for the first, let alone FY 2014 (ending June 30th 2014) which will be half over before the first licenses will even be granted.[6]

The second target number for which we provide a "worked example" assumes a smaller share of the market captured by I-502 stores (20%) and a larger average store size ($2M per year).[7] With these parameters, the number of stores recommended would be close to 200.

165	Total quantity consumed in state (MT)
20%	Market share of 502 market
$12	Revenue per gram (total, including all taxes)
$ 396	Total sales, for all stores ($M)
$ 2.00	Target average operating scale per store ($M)
198	Target number of stores (sent to other sheets in the workbook)

As more information becomes available on these parameters, this calculation can be revised.

Basic Allocation Strategies

Allocating Stores by Simple Proration

Prorating stores proportionally is mathematically simple, but raises the question as to the basis for the proration. One option would be to prorate stores based on each county's population. That approach appeals to a certain notion of fairness – all citizens of the state are treated equally – and reliability, since population is both well-measured and stable over time. Thus, for example, since King County has 29% of the state's population, the county would be allocated 29% of the total number of stores.

However, I-502 stores offer no particular value to non-users, and the prevalence of use varies around the state – not enormously, but by enough to show up in sub-state estimates produced by the National Survey on Drug Use and Health (NSDUH). So another

[6] Twenty-five percent not only yields a convenient number of 330 total stores to compare with the number of LCB liquor stores (332) in 2012, but it also reflects a plausible medium-term market share of I-502. The medical market currently may serve an estimated 15% of the statewide marijuana market (as explained in task 430-8(b)), with at least one known access point in counties containing almost 90% of the state's population. I-502 stores are likely to provide even broader access, better testing and labeling, as well as full legality with respect to state law. We thus increase the percent of the market captured to 25% to capture not only those currently served by access points, but those counties where legal access is currently not available.

[7] The previously mentioned $1.5 million-revenue store figure did not include taxes. Thus, total sales (excise and sales tax inclusive) need to be approximately $2 million.

option is prorating in proportion to an estimate of the number of past-month users in the county.

Task 430-Rd collected the number of PM users for each county using info such as the NSDUH, census data, treatment data and the Healthy Youth Survey.[8] For this task, we did a parallel analysis with preliminary figures to obtain the projected number of users by county in 2015, with results reported in the associated Excel workbook.

A brief description of the method is as follows. NSDUH estimates past prevalence for six regions within the state of Washington for four time periods (2002-2004, 2004-2006, 2006-2008, and 2008-2010), but does not provide estimates for individual counties. So this is a two-step process: (1) Forecast prevalence – and, hence, the number of past-month (PM) users – in each region in the relevant future year (we used 2015) and then (2) Parcel out that regional total to the different counties that make up the region. Each of those two steps can be done in several different ways, so there are many variants on this strategy of estimating PM prevalence at the county level, although the variants' results are generally in broad agreement.[9]

Allocating Stores by Multifactor Rules

The simple proration allocation rules consider only demand, but the LCB might also want to consider the physical size of the county. San Francisco and South Dakota have about the same population, but a number of retail outlets that serves San Francisco well would be woefully inadequate for South Dakota – with its much lower population density and greater area.

So we consider also two simple multifactor rules that take a linear sum of a measure of demand (the number of PM users) and a measure of geographic extent, one using area (in square miles) and the second using the square root of the area. The logic for using the square root of area is that area grows as the square of the distance across a region. Stretching a region out proportionally in a manner which quadruples its area would only double the travel distance between any pair of corresponding points. Thus, the square root method may better approximate travel distance to retail locations.

We would argue for the merits of the square root approach, but understand that it might strike some as overly complicated and so also include the method that uses area, not its square root.

Allocating Stores by These Methods – Spreadsheet Execution

This section explains the functionality of the workbook; it is provided for general understanding of the workbook's capability. Someone who wishes to actually perform computations with the workbook should also consult the accompanying user guide. Others

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[8] It is appropriate to focus on past-month users because those who have consumed in the past-year but not the past-month account for a quite small share of consumption. For a full explanation of this, see Kilmer et al. (forthcoming).

[9] For further explanation of this analysis, see the Task 430-Rd report (forthcoming).

should read this section for general knowledge of functionality, but should consult the workbook itself for specific details of these methods' calculations.

Each of the methods described in this section will update automatically as the total number of stores is adjusted on the first worksheet (described in section 2.0), but the actual total number of stores placed by each method will vary slightly due to rounding and the requirement that each county have a minimum of one store. The travel-distance minimizing method described in Section 4.0 does not update automatically; it involves additional computation that requires moderately advanced spreadsheet skills.

The worksheet "Allocation Rules" includes both simple proration rules (by population and number of users) and both multifactor rules (users and area, users and square root of area). The proration itself results in numbers that are not integers, so all are rounded to the nearest integer but with a minimum of 1 store per county. (Those columns are highlighted in blue.) Additional columns show the results of other rounding strategies; e.g., always rounding up to the next highest integer.

The number of cannabis users in each county was calculated by methods described in Task 430-Rd. These figures can be adjusted on the "Population Data" worksheet.

The two multifactor rules that consider county area involve a constant used to combine area (or its square root) with the number of users. These constants (4 for area and 75 for square root of area)[10] can be adjusted by the user; the initial values give area a moderate weight, less than what is assigned to the number of users, in determining the distribution of stores.[11]

All four of these methods, including their various rounding variants, update automatically if there are changes to the target total number of stores (which is computed on the first worksheet in the workbook).

The results of the travel-distance minimizing strategies described next can be pasted into the "Allocation Comparison Table" sheet to facilitate comparison across methods. More information on the variability between these methods is found in section 6.0.

Minimizing a Proxy (D) for the Average Distance to the Closest Store

Another approach to allocating stores is to minimize (a proxy for) the average distance that a user would need to travel to reach the closest store in his or her county. Computing the true average distance is not practical for two reasons: (1) There is not time to prepare and analyze detailed data on street grids and population distribution within each county and, in any event, (2) LCB does not know or directly control where licensees will place their stores within a county.

[10] We selected these constants simply as reasonable numbers which kept most of the emphasis on the number of PM users, but also brings area into the calculation in a non-negligible way.
[11] This could likewise be done using population instead of users. Additionally, other valued information could be incorporated, such as annual tourists, with their own weights.

So instead we minimize a proxy, D, for the average distance from any given user to the closest store.

The proxy would be exact if users (or population) were spread fairly uniformly around the county and stores were placed intelligently to maximize convenience, not all clustered together in one district. In practice, both of those conditions are violated. Most, if not all, of the counties have clustered rather than uniform populations, and retail stores are also likely to cluster in the same locations. To some extent these two facts offset each other. The stores will not necessarily be spread around the county because each entrepreneur will seek to maximize individual profit, not social welfare, but the clustering of customers – and the stores with them – will tend to reduce travel times relative to a more dispersed population.

The proxy uses a rule-of-thumb that the distance to the nearest retail location is some constant coefficient times the square root of (A/n), where A=the area of a county and n=the number of stores in that county. There are different guidelines for the constant. For example one uses 0.38 for travel as the crow flies and 0.5 for rectilinear travel (as in a Manhattan-like street grid).[12] It is not worth fussing much over the constant because its value has no effect on the store allocation. (Doubling a constant in front of an objective function to be minimized does not change the optimal "solution" which minimizes that objective.) The constant only affects the value of the solution – namely the estimated average travel distance. For that purpose we use a constant of 0.5.

Using the above formula, we can use nonlinear optimization to allocate the designated number of stores across counties in a way that minimizes the population-weighted average D over all the counties. Computationally this is a difficult optimization problem, because it is both nonlinear (because the square root of A/n) and integer valued (fractional stores make no sense). So the optimization is best accomplished in two steps.

This first step results in fractional numbers of stores (e.g., 2.85 stores allocated to county A). To reach an optimal integer solution, all allocated numbers of stores are rounded to the nearest integer. Rounding only produces a pretty good, not an optimal integer solution, and the number may no longer match the statewide target number of stores exactly. To move from a pretty good to an "optimal" integer solution, we calculate each county's average D (weighted for number of users) several ways: once with the current number of stores and again with both one more and one fewer. Those three figures are then used to fine tune the numbers in each county.

In particular, the spreadsheet identifies the county for which one additional store would decrease the average distance to the closest store the most, and the county for which one fewer store would increase the average distance the least. If the reduction in population-weighted travel time from adding a store to the first county is greater than the

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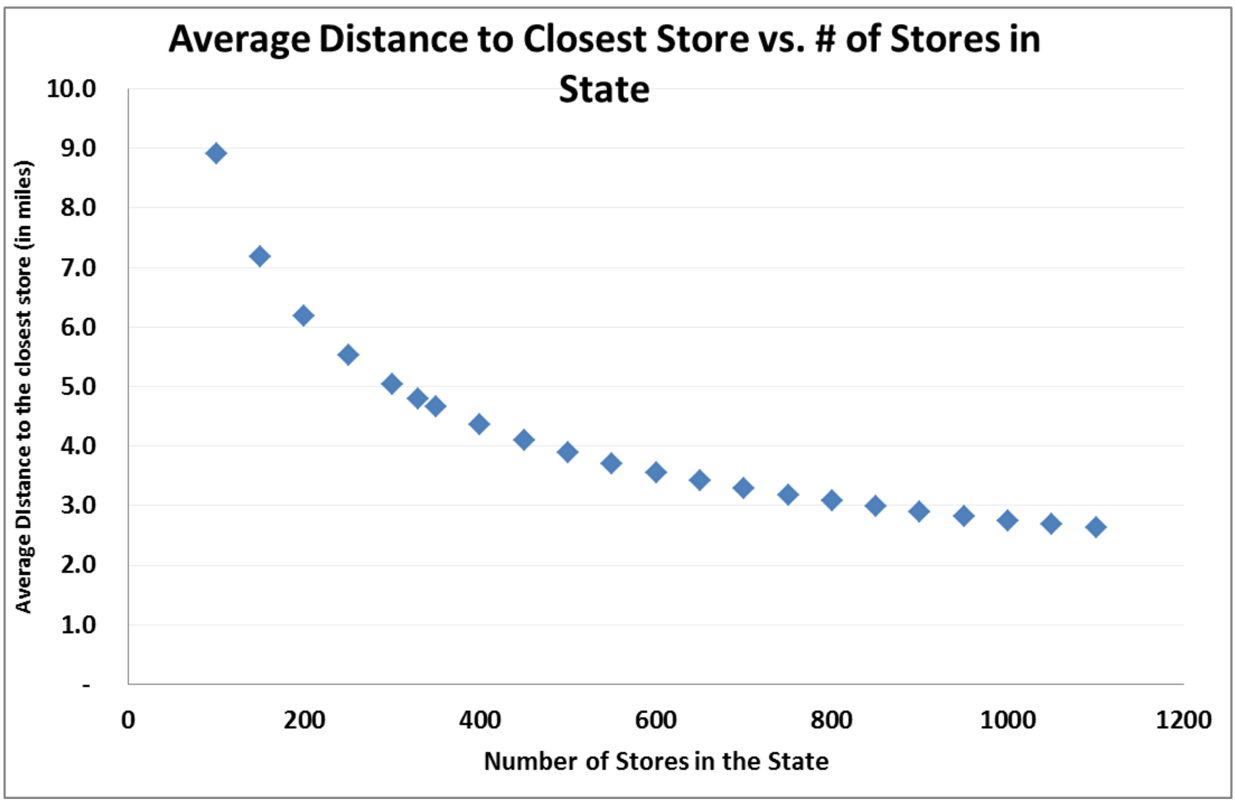
[12] The coefficient of 0.5 applies for rectilinear travel if the county can be broken up into store catchment areas each of which is approximately square. If the county's borders are irregular and it can only be "covered" by rectangles, not squares, the coefficient increases but not by much. E.g., if the county can only be broken up into irregular rectangles that are elongated, so that they are, on average, k times as long as they are wide, the coefficient becomes (k+1) / 4 *SQRT(k). So even if one has to use rectangles that are k = 4 times longer than they are tall – a significant departure from the ideal of squares – the coefficient only increases to (4+1) / (4*2) = 0.625.

increase in the 2nd county, then the user can move one store from the 2nd to the 1st county. In practice it doesn't take many such "switches" to reach the optimal integer-valued solution in which there is no way to move a store without making the total statewide travel time worse, not better.

The sheet "Min Avg D, by # of stores" shows the result of optimizing the store allocation for numbers of stores in the state ranging from 100 to 1100, in increments of 50, and graphs how the average distance to the closest store declines as the total number of stores increases. (Graph reproduced below.) Note that even with just 200 stores, we'd expect users, on average, to have to travel not much more than six miles to their closest store, and that distance decreases (but at a decreasing rate) as total number of stores increases. This bears on the question of how much more customer convenience is achieved, on average, by increasing from 200 to 300 and 400 or more stores in the state.



Assessing a Potential Allocation

The allocations determined by each "method" described above can be starting points, not necessarily final decisions of the LCB. The "Allocation Comparison Table" worksheet and adjacent worksheets can assist the LCB in reviewing a particular potential allocation and making manual adjustments to that allocation as desired.

The worksheet "Allocation Comparison Table" compares side-by-side the number of stores for each county from (a) the five allocation methods discussed above, (b) the historical number of LCB stores and current number of medical access points (dispensaries) listed by the site legalmarijuanadispensaries.com,[13] and (c) a custom or manually generated allocation (in Column M). The idea is that the LCB's current most-favored allocation would be placed in Column M and compared to the other columns.

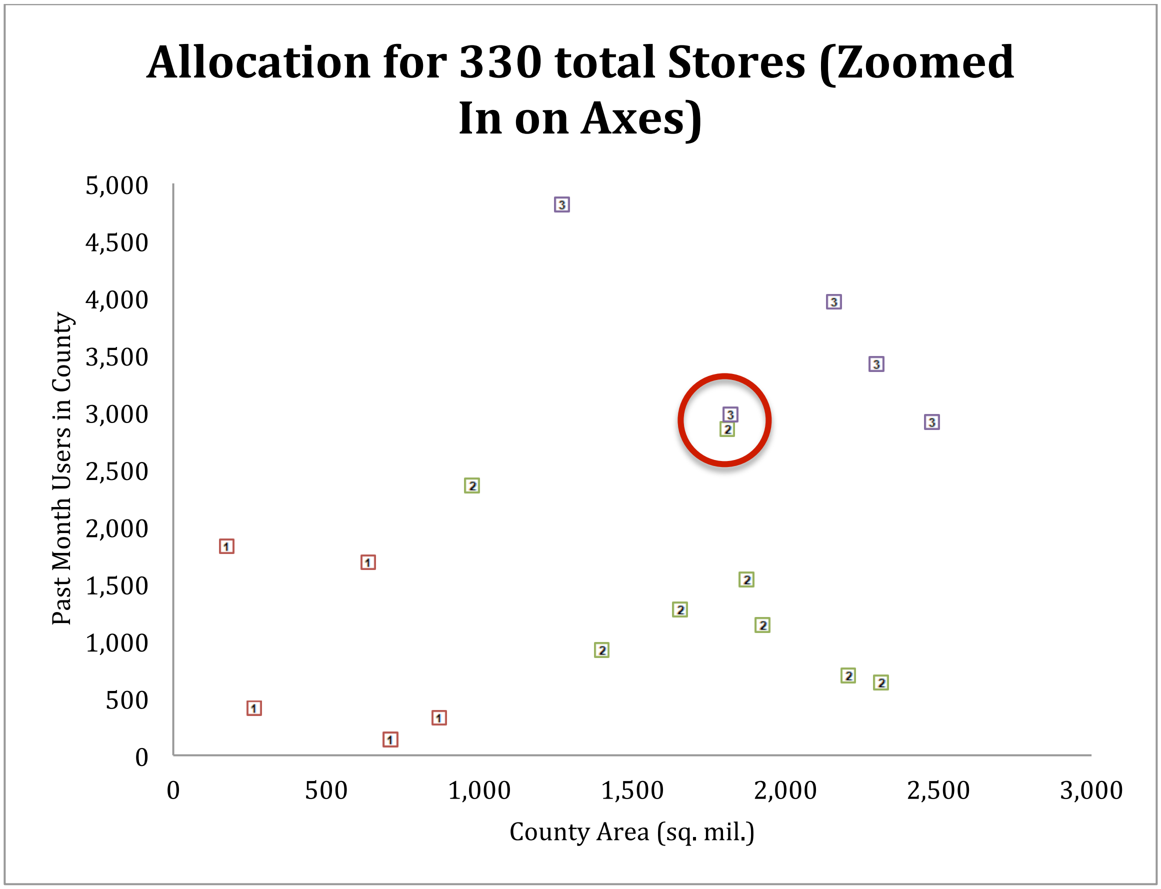
Most of the methods tend to be in broad agreement. This is illustrated by the table on the sheet "Correlations" which shows the cross-sectional correlation of numbers of stores for all pairs of methods (with a correlation of 1.000 indicating perfect agreement).

The LCB might be particularly concerned about equity across counties. The sheets "Plot, stores by users & area" and "Plot, stores by pop & area" contain scatter plots showing whether counties with approximately the same number of number of users (or population) and area are allocated the same number of stores. They usually will be, but not necessarily always. If two similar counties happen to fall just above and just below a cut-off threshold, a method might assign them different numbers of stores. These two sheets and their plots are intended to help LCB rapidly identify such situations.

The LCB may want to manually change a value for a county using this tool. For example, if two counties appear very similar in both number of users and area, but one is allocated an additional store, the LCB may add a store to the other county in order to avoid inequitable situations.

This tool can also help explain allocation decisions to interested parties. A snapshot of an example graph shows two stores near one another in both number of PM users and area, yet they are allocated a different number of stores. The LCB may choose to change one of those counties' allocations or simply use the graph as a guide to explaining the difference in allocation.

[13] Legalmarijuanadispensaries.com identifies 262 "access points" in Washington State, most of which list addresses suggesting a bricks and mortar location, but some describe themselves as "Deliveries only". We do not know how the website locates the dispensaries it lists and presumably could miss some; the Marijuana Business Factbook 2013 (p.83) estimates there are 300-350 marijuana stores in Washington, so legaldispensaries.com lists may be incomplete.



Demonstration and Illustration of Results

This section illustrates the similarities and differences in results when using the various methods to allocate stores among counties for two different target total numbers of stores. The workbook not only provides the tools to "calculate" store allocations for individual methods, but also provides ways of comparing each method to each other at the county level.

For these exercises we based the number of PM users on a projection of prevalence out to 2015 using the data sources available, so the absolute numbers are a little higher than what would pertain today, but that makes almost no difference for the allocation of a fixed number of stores, because that is based on relative number of users in each county, not the absolute number.

Below is a table summarizing the five allocation methods, their type and a simple explanation of the calculation used, to be used a quick reference in this section to the more detailed explanations in previous sections.

Method	Type	Calculation
By Population	Simple Proration	Stores X county % of population
By Users	Simple Proration	Stores X county % of users
By Linear Rule, with Area	Multifactor	Stores X county % of users + 4(area)
By Linear Rule, with SQRT(Area)	Multifactor	Stores X county % of users + 75(square root(area))
Optimized Users and Area	Minimizing proxy for distance, D	Optimized using the Solver analysis tool

Illustration of Results for 330 Stores

We consider first the scenario of 330 stores statewide, as presented in the June 13th briefing. As noted above, this value may be a fair approximation for two or so years in the future, once I-502 stores capture ~25% of the entire marijuana market.

The initial proration assigns non-integer numbers of stores that exactly matches the target of total stores as described in section 2.0, but the actual resulting total number of stores will vary slightly across allocation methods due to rounding and the requirement that there be at least one store per county. With a target of 330, the methods actually yield the following totals:

	By Population	By Users	By Linear Rule, with Area	Linear Rule, with SQRT(Area)	Optimized Users & Area
Total	**335**	**333**	**328**	**334**	**330**

In order to hit precisely 330 stores (or any other total) for any given method, the user must use Excel's "Goal Seek" or manually adjust the input cell (cell A1 on the worksheet) incrementally to achieve the desired output.[14] Below is an example of the comparisons between the five allocation techniques after they have been manually adjusted to yield exactly 330 total stores. Additionally, the number of LCB liquor stores in 2012 (332 total) in each county is also listed for comparison.

[14] This, however, will remove cell A1's ability to autopopulate. Currently, cell A1 on the worksheet "Allocation Rules" is updated automatically from cell A9 on the worksheet "Compute # of Stores for State". Manually changing cell A1 would eliminate this automatic update.

County	Population	# of PM Users	Area (sq mi)	By Population	By Users	By Linear Rule, with Area	Linear Rule, with SQRT(Area)	Optimized Users & Area	LCB Stores 2012
Adams	19,005	1139	1,925	1	1	3	2	2	3
Asotin	21,888	1688	636	1	1	1	1	2	2
Benton	182,398	12952	1,703	9	6	7	6	9	5
Chelan	73,687	6289	2,922	3	3	6	4	7	5
Clallam	71,863	9228	1,745	3	4	6	5	7	4
Clark	438,287	40796	628	21	19	15	17	14	13
Columbia	3,995	330	869	1	1	1	1	1	1
Cowlitz	101,996	11475	1,139	5	5	6	6	7	5
Douglas	39,350	2983	1,821	2	1	4	2	3	3
Ferry	7,705	696	2,204	1	1	3	2	1	1
Franklin	85,845	6156	1,242	4	3	4	4	5	3
Garfield	2,228	136	710	1	1	1	1	1	1
Grant	91,723	6464	2,681	4	3	6	4	7	10
Grays Harbor	71,692	9090	1,917	3	4	6	5	7	8
Island	79,177	8062	209	4	4	3	4	3	5
Jefferson	29,854	2851	1,809	1	1	3	2	3	4
King	2,007,440	204297	2,126	94	96	74	84	60	74
Kitsap	254,991	27999	396	12	13	10	12	9	8
Kittitas	41,672	3419	2,297	2	2	4	3	4	3
Klickitat	20,699	1538	1,872	1	1	3	2	2	2
Lewis	75,621	8123	2,408	4	4	6	5	7	8
Lincoln	10,437	634	2,311	1	1	3	2	1	4
Mason	60,832	6393	961	3	3	4	4	5	5
Okanogan	41,275	3336	5,268	2	2	8	4	5	8
Pacific	20,575	2357	975	1	1	2	2	2	6
Pend Oreille	12,980	920	1,400	1	1	2	2	1	3
Pierce	811,681	81329	1,676	38	38	31	34	30	33
San Juan	15,824	1825	175	1	1	1	1	1	4
Skagit	118,222	19102	1,735	6	9	9	9	12	7
Skamania	11,187	1275	1,656	1	1	3	2	2	1
Snohomish	733,036	78057	2,090	35	37	30	33	32	25
Spokane	475,735	40387	1,764	22	19	16	18	19	22
Stevens	43,538	2915	2,478	2	1	4	3	4	6
Thurston	258,332	26350	727	12	12	10	11	11	10
Wahkiakum	3,993	411	264	1	1	1	1	1	1
Walla Walla	59,404	4816	1,270	3	2	3	3	4	2
Whatcom	205,262	30378	2,120	10	14	13	14	17	12
Whitman	46,606	3966	2,159	2	2	4	3	4	5
Yakima	246,977	23806	4,296	12	11	14	12	18	10

The biggest takeaway from the table above is that all methods produce broadly similar allocations for each county. In fact, only 14 of the 39 counties (36%) have a difference of more than 3 stores between their minimum and maximum allocation. Additionally, each method is highly correlated with one another, with correlation coefficients exceeding 0.96 for each pair of methods.

	By Population	*By Users*	*By Linear Rule, with Area*	*Linear Rule, with SQRT(Area)*	*Optimized Users & Area*
By Population	1.000	0.997	0.991	0.996	0.968
By Users		1.000	0.994	0.999	0.972
By Linear Rule, with Area			1.000	0.997	0.981
Linear Rule, with SQRT(Area)				1.000	0.977
Optimized Users & Area					1.000

Even with this high correlation, the decision to use one method over another will affect the allocated number of stores in some counties. For example, choosing a method which gives greater weight to area (or even includes it as a factor) will allocate more stores to a county like Okanogan or Lewis than a highly populated area like King or Pierce County. The accompanying workbook will assist LCB staff in choosing a final allocation, taking these and other factors into account.

A table of numbers with 39 rows and 6 or 7 columns, most of whose entries are the same, is hard to digest. To help highlight the differences, we calculate the variability across columns as a measure of variation across methods. The coefficient of variation (CV) is the ratio of the standard deviation to the average number of stores allocated to each county. A larger number indicates greater variability. The difference between the minimum and maximum values and the ratio of that difference to the average also provide insight into the variability of the allocation over each method.

Variation Across Allocation Method (Explanation of Color Scheme in Following Text)

County	By Population	By Users	By Linear Rule, with Area	Linear Rule, with SQRT(Area)	Optimized Users & Area	Coeff of Var across methods	Max - Min	(Max - Min) / Avg
Adams	1	1	3	2	2	0.46	2	1.11
Asotin	1	1	1	1	2	0.37	1	0.83
Benton	9	6	7	6	9	0.20	3	0.41
Chelan	3	3	6	4	7	0.39	4	0.87
Clallam	3	4	6	5	7	0.32	4	0.80
Clark	21	19	15	17	14	0.17	7	0.41
Columbia	1	1	1	1	1	0.00	0	0.00
Cowlitz	5	5	6	6	7	0.14	2	0.34
Douglas	2	1	4	2	3	0.48	3	1.25
Ferry	1	1	3	2	1	0.56	2	1.25
Franklin	4	3	4	4	5	0.18	2	0.50
Garfield	1	1	1	1	1	0.00	0	0.00
Grant	4	3	6	4	7	0.34	4	0.83
Grays Harbor	3	4	6	5	7	0.32	4	0.80
Island	4	4	3	4	3	0.15	1	0.28
Jefferson	1	1	3	2	3	0.50	2	1.00
King	94	96	74	84	60	0.18	36	0.44
Kitsap	12	13	10	12	9	0.15	4	0.36
Kittitas	2	2	4	3	4	0.33	2	0.67
Klickitat	1	1	3	2	2	0.46	2	1.11
Lewis	4	4	6	5	7	0.25	3	0.58
Lincoln	1	1	3	2	1	0.56	2	1.25
Mason	3	3	4	4	5	0.22	2	0.53
Okanogan	2	2	8	4	5	0.59	6	1.43
Pacific	1	1	2	2	2	0.34	1	0.63
Pend Oreille	1	1	2	2	1	0.39	1	0.71
Pierce	38	38	31	34	30	0.11	8	0.23
San Juan	1	1	1	1	1	0.00	0	0.00
Skagit	6	9	9	9	12	0.24	6	0.67
Skamania	1	1	3	2	2	0.46	2	1.11
Snohomish	35	37	30	33	32	0.08	7	0.21
Spokane	22	19	16	18	19	0.12	6	0.32
Stevens	2	1	4	3	4	0.47	3	1.07
Thurston	12	12	10	11	11	0.07	2	0.18
Wahkiakum	1	1	1	1	1	0.00	0	0.00
Walla Walla	3	2	3	3	4	0.24	2	0.67
Whatcom	10	14	13	14	17	0.18	7	0.51
Whitman	2	2	4	3	4	0.33	2	0.67
Yakima	12	11	14	12	18	0.21	7	0.52

The individual values for each indicator are not particularly significant (e.g. it is not the case that greater than one is bad and less than one is good), but we color code the entries to distinguish high values (in red) from low values (in green). The red indicates counties for which there was relatively greater disagreement across methods; those are counties whose allocation might merit further thought and perhaps manual adjustment.

For example, the difference between the maximum and minimum number of stores in King County is flagged because it is a large number. That difference is large mainly because King County is so populous and, hence, is allocated many stores by all rules. If one considers the CV or the absolute difference divided by the average number allocated to a county, the allocation methods no longer seem so far out of synch in their recommendations for King County. Looking at individual numbers, the method attempting to minimize the proxy distance (D) explains most of this difference. If LCB wanted to use that particular method, but thought 60 was far too low a number for King County, the staff could manually increase the number of stores for that individual county.

Okanogan County similarly has the highest CV and (Max-Min)/Average. The three methods which include area as a parameter, particularly the linear rule, allocate a far greater number of stores to Okanogan County than do the simple proration methods. Okanogan County is the largest county by land area, but it ranks in the bottom half for number of users. If the county's population is clustered in several areas, a lower number of stores might be appropriate. However, if there is a large, dispersed rural population, LCB may want to allocate a higher number to that county.

Interpretation of Results for 200 Stores

In order to provide more insight into this tool, we provide the same tables shown above using 198 total stores as the starting point (from section 2.0). Here, the 198 was automatically used as an input for the first four methods, and the values for 200 stores optimized to minimize D were copied into the worksheet.[15] The totals (shown below) do not equal 198 for any method, due to rounding and requiring one store for each county. To achieve 198 stores for each method, the user could manually adjust the input for each method as described in section 6.1. Here, however, we leave it as produced from the workbook to illustrate the actual output you will see.

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[15] Optimization may be used for any value of stores, but the allocations are already provided for any multiple of 50 from 100 to 1100. Thus, these tables show what can quickly be done to compare allocations for particular totals.

County	Population	# of PM Users	Area (sq mi)	By Population	By Users	By Linear Rule, with Area	Linear Rule, with SQRT(Area)	Optimized Users & Area	LCB Stores 2012	Known Medical Access Points, 2013
Total				**204**	**208**	**200**	**200**	**200**	**332**	**262**
Adams	19,005	1139	1,925	1	1	2	1	1	3	0
Asotin	21,888	1688	636	1	1	1	1	1	2	0
Benton	182,398	12952	1,703	5	4	4	4	5	5	0
Chelan	73,687	6289	2,922	2	2	4	3	4	5	0
Clallam	71,863	9228	1,745	2	3	3	3	4	4	3
Clark	438,287	40796	628	13	12	9	10	8	13	9
Columbia	3,995	330	869	1	1	1	1	1	1	0
Cowlitz	101,996	11475	1,139	3	3	3	3	4	5	1
Douglas	39,350	2983	1,821	1	1	2	2	2	3	0
Ferry	7,705	696	2,204	1	1	2	1	1	1	0
Franklin	85,845	6156	1,242	2	2	2	2	3	3	0
Garfield	2,228	136	710	1	1	1	1	1	1	0
Grant	91,723	6464	2,681	3	2	4	3	4	10	0
Grays Harbor	71,692	9090	1,917	2	3	3	3	4	8	3
Island	79,177	8062	209	2	2	2	2	2	5	0
Jefferson	29,854	2851	1,809	1	1	2	1	2	4	1
King	2,007,440	204297	2,126	58	58	44	51	36	74	125
Kitsap	254,991	27999	396	7	8	6	7	6	8	7
Kittitas	41,672	3419	2,297	1	1	3	2	2	3	0
Klickitat	20,699	1538	1,872	1	1	2	1	1	2	0
Lewis	75,621	8123	2,408	2	2	4	3	4	8	2
Lincoln	10,437	634	2,311	1	1	2	1	1	4	0
Mason	60,832	6393	961	2	2	2	2	3	5	3
Okanogan	41,275	3336	5,268	1	1	5	2	3	8	0
Pacific	20,575	2357	975	1	1	1	1	2	6	0
Pend Oreille	12,980	920	1,400	1	1	1	1	1	3	0
Pierce	811,681	81329	1,676	23	23	18	21	18	33	34
San Juan	15,824	1825	175	1	1	1	1	1	4	0
Skagit	118,222	19102	1,735	3	5	5	5	7	7	4
Skamania	11,187	1275	1,656	1	1	2	1	1	1	0
Snohomish	733,036	78057	2,090	21	22	18	20	19	25	19
Spokane	475,735	40387	1,764	14	12	10	11	12	22	16
Stevens	43,538	2915	2,478	1	1	3	2	2	6	0
Thurston	258,332	26350	727	7	8	6	7	6	10	22
Wahkiakum	3,993	411	264	1	1	1	1	1	1	0
Walla Walla	59,404	4816	1,270	2	1	2	2	3	2	0
Whatcom	205,262	30378	2,120	6	9	8	8	10	12	11
Whitman	46,606	3966	2,159	1	1	3	2	3	5	1
Yakima	246,977	23806	4,296	7	7	8	7	11	10	1

Additionally, below we again show the measures of variability for these allocations. Note that the same two counties highlighted in the previous section (Okanagan and King) also display the highest values here. The proportional distribution of stores does not drastically change as the total number of stores changes.

<u>Variation Across Allocation Method (Explanation of Color Scheme in Text)</u>

County	By Population	By Users	By Linear Rule, with Area	Linear Rule, with SQRT(Area)	Optimized Users & Area	Coeff of Var across methods	Max - Min	(Max - Min) / Avg
Adams	1	1	2	1	1	0.37	1	0.83
Asotin	1	1	1	1	1	0.00	0	0.00
Benton	5	4	4	4	5	0.12	1	0.23
Chelan	2	2	4	3	4	0.33	2	0.67
Clallam	2	3	3	3	4	0.24	2	0.67
Clark	13	12	9	10	8	0.20	5	0.48
Columbia	1	1	1	1	1	0.00	0	0.00
Cowlitz	3	3	3	3	4	0.14	1	0.31
Douglas	1	1	2	2	2	0.34	1	0.63
Ferry	1	1	2	1	1	0.37	1	0.83
Franklin	2	2	2	2	3	0.20	1	0.45
Garfield	1	1	1	1	1	0.00	0	0.00
Grant	3	2	4	3	4	0.26	2	0.63
Grays Harbor	2	3	3	3	4	0.24	2	0.67
Island	2	2	2	2	2	0.00	0	0.00
Jefferson	1	1	2	1	2	0.39	1	0.71
King	58	58	44	51	36	0.19	22	0.45
Kitsap	7	8	6	7	6	0.12	2	0.29
Kittitas	1	1	3	2	2	0.46	2	1.11
Klickitat	1	1	2	1	1	0.37	1	0.83
Lewis	2	2	4	3	4	0.33	2	0.67
Lincoln	1	1	2	1	1	0.37	1	0.83
Mason	2	2	2	2	3	0.20	1	0.45
Okanogan	1	1	5	2	3	0.70	4	1.67
Pacific	1	1	1	1	2	0.37	1	0.83
Pend Oreille	1	1	1	1	1	0.00	0	0.00
Pierce	23	23	18	21	18	0.12	5	0.24
San Juan	1	1	1	1	1	0.00	0	0.00
Skagit	3	5	5	5	7	0.28	4	0.80
Skamania	1	1	2	1	1	0.37	1	0.83
Snohomish	21	22	18	20	19	0.08	4	0.20
Spokane	14	12	10	11	12	0.13	4	0.34
Stevens	1	1	3	2	2	0.46	2	1.11
Thurston	7	8	6	7	6	0.12	2	0.29
Wahkiakum	1	1	1	1	1	0.00	0	0.00
Walla Walla	2	1	2	2	3	0.35	2	1.00
Whatcom	6	9	8	8	10	0.18	4	0.49
Whitman	1	1	3	2	3	0.50	2	1.00
Yakima	7	7	8	7	11	0.22	4	0.50

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