

Estimating Farmworker Population Size in New York State Using a Minimum Labor Demand Method

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ABSTRACT. *Assessment of health needs and services for hand-harvest farmworkers requires reliable population estimates. In New York State, the only publicly available source for these is the Department of Labor (DOL). However, published production data exist that may enable estimation of minimum labor demand (MLD) for hand-harvest labor. Our objective was to develop an estimation process for minimum labor demand (MLD) for hand-harvested crops in NYS and contrast the results with DOL estimates. Four crop strata (below ground, ground, bush/vine, and orchard) were identified. MLD (measured in worker-seasons) was estimated by dividing the total annual harvest hours required for each crop stratum by the total hours worked by one worker in a season for that crop stratum. The MLD estimate of the total number of worker seasons combined for all strata (14,121) was higher than that of the DOL (8,230). Harvest acreage was unavailable for 21% of the 991 county-crop combinations studied; therefore, data were imputed from other sources. Within these strata, the greatest difference was found for ground crops, where the DOL count was 28% of the size of the MLD estimate. DOL and MLD estimates were closest in orchard crops (DOL 109% of MLD). Publicly available data provide a potentially valuable source of information for estimation of the MLD. Use of these methods implies that the DOL may substantially underestimate the size of this population. Differences seen between the two methods were sensitive to the crop type. County-level farm surveys to verify MLD estimation factors would enhance the method's accuracy.*

Keywords. *Farmworker estimates, Geographic distribution, Migrant farmworkers, Seasonal farmworkers, Agricultural workers.*

Agriculture is a dangerous industry. According to 2001 data, U.S. agriculture has an occupational fatality rate of 21.3 per 100,000 workers, over five times the all-industry rate of 3.9. In nonfatal work injuries, agriculture also ranks among the highest (NSC, 2002).

Within agriculture, different types of workers may experience very different hazards. Harvesting crops by hand requires a great deal of stooping, bending, reaching, lifting

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heavy weights, and holding awkward postures for extended periods. Migrant and seasonal farmworkers most commonly do this work.

Migrant and seasonal farmworkers are most often hired on a temporary basis, without benefits or protections other workers enjoy. They are often paid piece-rate, under time pressure of a short harvest period, which discourages adequate breaks and rest. Many workers are foreign-born and experience cultural and linguistic isolation, uncertain legal status, and extreme dependency upon the employer, which further exacerbates occupational safety risks (Mobed et al., 1992; Villarejo, 2003; Wilk, 1998). Given the organizational structure of this industry, it is unlikely that OSHA reporting mechanisms will ever accurately reflect illness and injury rates.

Outside of workplace reporting, injury surveys (McCurdy et al., 2003; McGwin et al., 2000; Ciesielski et al., 1991; McDermott and Lee, 1990; Isaacs and Bean, 1995), Worker's Compensation record review (Villarejo, 1998), and agricultural injury surveillance through medical care providers and law enforcement (Osorio et al., 1998; Earle-Richardson et al., 2003) have been used to assess the extent of occupational injury and illness among migrant and seasonal farmworkers.

Each of these methods has limitations. Self-reported farm injuries have no medical documentation of the type and severity of conditions. In addition, accurate subject injury recall of the occurrence of an injury event has been shown to be limited to relatively short intervals of time (Jenkins et al., 2002; Hwang et al., 2001). There may also be some social acceptability biases against reporting injuries (Earle-Richardson et al., 1998).

Worker's compensation claims and injury surveillance methods have the advantage of providing greater detail about recorded events. However, worker's compensation data may miss injuries for which no medical care was sought or for which filing of claims was discouraged for any of a variety of reasons. In addition, these methods are limited by the fact that they rely on uncertain farmworker population estimates as a denominator in risk estimation. The difficulty in obtaining reliable estimates has led some researchers to present injury data without risk estimates (Osorio et al., 1998, Earle-Richardson et al., 2003). The conclusions that can therefore be drawn from these data are quite limited.

In order to collect detailed occupational injury and illness data on migrant and seasonal farmworkers in New York and the Northeast, we have conducted three years of occupational injury surveillance based in federally supported migrant health centers in New York, Pennsylvania, New Jersey, Massachusetts, Maine, Connecticut, and Maryland. The rationale and surveillance model has been described elsewhere (Earle-Richardson et al., 2003). During the last two seasons, reports of 1,422 cases of occupational injury or illness have been collected across these seven states. Unfortunately, interpretation of these data is again hampered by inadequate counts of the total farmworker population at risk.

Before using existing migrant and seasonal farmworker population estimates (provided by state departments of labor), we wished to use any available means to assess their accuracy. One of us (Larson) has developed, and made use of in previous research (Larson and Placencia, 1993; Larson, 2000), a method for estimating the labor demand in worker hours that can be readily converted into worker season equivalents by crop. In the current analysis, this method is adapted for use in New York State using available state production and productivity data. The main objective of this analysis is to pilot the minimum labor demand estimation process, determine if it feasible to estimate the labor demand with published data, and identify obstacles to making this estimate. Secondly, if a minimum labor demand estimate is obtained, researchers wish to see what light these data shed on current DOL counts.

A minimum number of worker-season equivalents (worker-seasons) are estimated using this process to determine what would be the smallest labor force capable of

harvesting the state’s annual hand-harvest. This estimate is then compared to current Department of Labor (DOL) population counts. In the current analysis, these comparisons are made within four distinct crop type strata: below ground, ground, bush/vine/corn, and orchard fruit.

The crop strata were devised based on predominant body posture and work activity involved with hand-harvest work. Below ground crops require stooping, pulling, and sometimes digging, whereas ground-level crops generally only require stooping and cutting. Bush/vine/corn were grouped together due to the standing posture and the general chest-height picking activity. Orchard work requires climbing, reaching, and extensive overhead picking. The individual crops in each category are shown in table 1. These groupings have been used in previous injury research for identifying commodity specific hazards.

A similar demand for a labor estimation process was used by Villarejo (1998) in estimating injury incidence from worker’s compensation claim data in California. Worker-weeks required to harvest the various crops were calculated from production data and validated with employer survey data. In the current analysis, the process is the reverse: the DOL count is in essence an employer survey of the number of persons employed, which we seek to evaluate by comparing it to a production-based estimate. Both DOL and minimum labor demand (MLD) estimates are compared within four major crop groups and by geographic region.

Methods

Department of Labor Estimation

The New York State Department of Labor maintains a registry of farms employing five or more seasonal workers and of contractors employing any number of workers (NYS Department of Labor, 2000, unpublished). Participation in this registry is mandatory and allows the DOL to ensure that employers are complying with New York State employment law. This registry was used as a basis for the DOL counts because it provides estimates at the county level. Other available DOL worker counts do not provide this level of detail. (The Department of Labor’s Division of Employment Services also publishes a similar estimate of domestic and foreign seasonal agricultural workers based on the activities of its field representatives. These data are not available at the county or crop level and so were not used in the current analysis.)

The registry is set up in such a way that it avoids duplication of worker counts by contractors and the actual farm that the contractor supplies. This is ensured by requiring registration of workers only by the paying entity (personal communication, 30 May 2003, M. Burkhardt, NYS Dept. of Labor, Albany, N.Y.). For each farm, the registry contains a listing of one or more harvest work crews, the number of workers within each crew, the dates of service, and the crop or crops harvested by the farm.

Table 1. Hand-harvested crops in New York State by crop strata, 2000.

Below ground:	Dry onions, green onions, potatoes, radishes.
	Asparagus, broccoli, Brussels sprout, cantaloupe, cauliflower, Chinese cabbage, collards, cucumbers, eggplant, endive, escarole, head cabbage, herbs, hot peppers, kale, lettuce, mustard greens, mixed vegetables, other vegetables, parsley, pumpkins, rhu- barb, spinach, squash, strawberries, sweet peppers, tomatoes, watermelons.
Ground crops:	
Bush/vine/corn:	Berries, grapes, raspberries, sweet corn, tame blueberries.
Orchard fruit:	Apples, peaches, pears, plums/prunes, sweet cherries.

Initial adjustments were made to the DOL counts to make them directly comparable to the MLD. First, since the population of interest in this analysis is food crop hand-harvest workers, all registrants not harvesting crops listed in table 1 were eliminated. Farms growing only trees, shrubs, sod, nursery stock, flowers, container plants, holiday blooming plants, or producing dairy products, or food processing were eliminated. Since the “other food crop category” was not analyzable, and it occurred infrequently, it was excluded without counting any workers. Additional farms were eliminated, despite having a crop included in table 1, when the work description involved a process other than harvesting, such as canning, food processing, or off-farm packing. This process reduced the original list of 438 farms to 383.

Next, certain work crews were excluded if their dates of service did not correspond to the harvest season of any of the crops listed on the farm’s registration form (NYS Department of Agriculture and Markets, 2001).

Each registrant could list one or more crews and one or more crops harvested. For those farms listing only one crop, or multiple crops that all fit into one of the four crop strata, all worker-seasons were assigned to that stratum regardless of the number of crews.

For farms listing multiple crews and multiple crops fitting into more than one of the four crop strata, dates of service were employed to ascertain which crop each crew harvested. Specifically, if a crew’s date of service indicated that workers were present during a listed crop’s harvest season, it was assumed that workers harvested that crop. If this resulted in a crew being assigned to crops that fell within more than one stratum and that were harvested simultaneously, then the total numbers of workers in the crew were divided equally among the crops listed. If the crops were not harvested simultaneously (i.e., were harvested at different times of the year), the workers were assumed to have worked multiple seasons. In this case, the worker-seasons were assigned to both of the crop strata.

The worker seasons were then totaled within each of the four strata. It should be noted that the number of actual workers physically present in the state would be some value less than this, which is reflective of the fact that some workers work multiple seasons.

Minimum Labor Demand Estimation

The MLD approach calculates the total number of hours required to harvest a given commodity (THR) and then divides this by the number of hours contributed during the entire harvest season by an average worker (THC). The total number of hours required may be estimated as:

$$\text{THR} = \text{Total harvest acres} \times \text{Hours required for one worker to harvest one acre}$$

where total harvest acreage is either available in published sources or imputed (as described below), and the hours required to harvest one acre is available through published industry data. The number of hours contributed by an average worker during an entire season (THC) is estimated as:

$$\text{THC} = \text{Number of days in the season} \times \text{Number of hours worked per day}$$

where the number of days in the season and the number of hours worked per day are both obtained from published data. Both the THR and THC are specific to each crop stratum. The minimum labor demand in units of worker seasons for each crop stratum ($\text{MLD}_{\text{WS/crop}}$) is then estimated as:

$$\text{MLD}_{\text{WS/crop}} = \text{THR} / \text{THC}$$

An example of the calculation of worker-seasons is provided in Appendix 1.

Identification of Hand-Harvested Crops

The initial step in estimating the MLD was the identification of all hand-harvested crops in New York State. This list was created based on industry data (AFOP, 1999; USDA, 1999) and discussions with expert sources at Cornell University (New York's land grant university) (personal communication, 2001, S. Reiners, Cornell University, Geneva, N.Y.; personal communication, 2001, G. White, Cornell University, Ithaca, N.Y.). This resulted in the identification of the 42 crops shown in table 1.

This process also resulted in the identification of several crops that may have been either hand or machine harvested depending upon the county. These included apples, beets, cabbage, carrots, cherries, cucumbers, garlic, grapes, green peas, pears, snap beans, sweet corn, tomatoes, and watermelons. In these instances, experts were relied upon to establish which of the two methods were used for each county. In counties where 100% of crop harvest was mechanized, the crop-county combination was removed from the estimation process.

Determination of Total Acres Harvested

County-level estimates of harvest acreage for the 42 hand-harvested crops were obtained from the 1997 Census of Agriculture (USDA, 1999). For 38 of these 42 crops, data were not available for certain counties for confidentiality reasons (i.e., counties with low acreage or a small number of farms where data might be traceable to individual farms). Where this occurred, county-level harvest acres were imputed.

This imputation process consisted of three steps. First, the total acreage contained in the missing counties was determined by subtracting the sum of the available county-level acreage from the statewide total acreage. This total unassigned acreage was divided by the total number of farms in counties with missing acreage data to estimate the average acreage per farm. This average was then multiplied by the number of farms in each county with missing acreage data to impute the county-level value. An example of imputation of missing acreage is provided in Appendix 2.

Each crop also included a listing for "all other counties." This is a combined listing of counties where either the total number of farms in the county is less than three, or one farm contains more than 60% of the total county acreage for that particular crop (personal communication, 2004, W. Blackman, Albany, N.Y.). The acres contained within this category were not included in the total harvest acreage for the crop in question.

It was determined that grapes, head cabbage, and sweet corn were harvested by both hand and mechanized means within single counties (personal communication, 2001, S. Reiners, Cornell University, Geneva, N.Y.; personal communication, 2001, G. White, Cornell University, Ithaca, N.Y.; USDA, 1999). To correct for this, harvest acreage estimates for grapes were multiplied by 0.97 in all counties. Sweet corn acreage in all counties was multiplied by either 0.20 or 0.50 depending on the county. Certain counties received a correction of 0.02 for head cabbage.

The reduction factor for grapes was derived from the fact that 100% of juice grapes, which constitute 70% of all grapes, and 90% of wine grapes, which constitute the remaining 30%, are mechanically harvested. The reduction factor for sweet corn was derived from the fact that 80% of sweet corn is harvested mechanically in six New York counties. The four counties harvesting head cabbage by a combination of hand and machine methods typically harvest 98% of the total by machine.

The 1997 Census of Agriculture did not list harvest acreage for seven of the 42 crops. These included grapes and all six crops comprising the orchard stratum. For these crops, it was necessary to estimate harvest acres from production acres and from acres of trees or vines of bearing age, which were both publicly available at the statewide level (USDA,

2003). Production acres refer to the total acres owned by a farm, rather than those harvested.

First, county-level production acreage values were imputed for those counties where these data were not published using an analogous method to that described above for imputing missing county-level harvest acreage. Next, the proportion of production acres with trees or vines of bearing age was estimated by dividing the state's total acres with trees or vines of bearing age by its total production acres. Each county's production acres were then multiplied by this value to obtain harvest acres. An example of calculation of the acreage proportion and calculation of harvest acreage is provided in Appendix 3.

The acres of bearing age for plums and prunes were not available. Therefore a tree proportion was calculated by dividing the number of trees of bearing age by the total number of trees for the state (USDA, 1999). This tree proportion then replaced the statewide acreage proportion in the method described in the previous paragraph.

Additionally, for berries, the best available data were found in the 1992 Census of Agriculture in the form of total harvested acres. This value was reduced by 3% to account for a 3% loss of total farms from 1992 to 1997 (USDA, 1999).

Harvest acreage was also not available for sweet cherries, which were not included in the 1992 or 1997 Census of Agriculture. However, by using the total production acreage of cherries minus the total production acreage of tart cherries, which are harvested mechanically, the production acreage of sweet cherries could be derived. Harvest acreage was then estimated as described above for orchard fruit.

Estimation of Hours for One Worker to Harvest One Acre

Primary sources used for determining the number of hours required to harvest one acre of each crop included enterprise crop budgets prepared for New York. Other state crop enterprise budgets were substituted when New York data were not available for a given crop (personal communication, 2001, P. Smallidge, Cornell University, Ithaca, N.Y.; Rutgers Cooperative Extension, 1997; Pennsylvania State University, 1998).

Estimation of Number of Hours Worked Per Day

The only data available on the average length of the workday came from the Department of Labor farmworker employer registry. Registrants are asked to estimate the average length of a workday for their seasonal employees. The 438 registrants reported a mean workday length of 8.8 hours.

Estimation of Number of Days in Season

Information on harvest season length for each crop was obtained from both federal and state sources (USDA, 1997; NYS Department of Agriculture and Markets, 2001), and when published data were not available, from expert knowledge (telephone conversation, 17 Oct. 2001, Steve Reiners, Cornell University, Ithaca, N.Y.). The calendar weeks spanned the start date to the stop date of the harvest season and were converted to work days by multiplying by 5.625, the average number of days worked per week as estimated from the Department of Labor data.

Results

Department of Labor Estimation

The Department of Labor dataset contained 438 records, which yielded 383 eligible farms and contractors. As described in the Methods section, 50 of these were eliminated either due to having an excluded crop or because the work description involved a process other than harvesting, such as canning, food processing, or off-farm packing.

A total of 8,230 worker-seasons were identified from this DOL data. Table 2 shows the distribution of these worker-seasons over the four crop groups, ranging from 602 worker-seasons (below ground) to 5,421 worker-seasons (orchard fruit).

Minimum Labor Demand Estimation

Crop-specific harvest acres, hours to harvest one acre, and total season hours contributed by one worker are listed in Appendix 4. It was necessary to impute county-level acreage for at least one county for 38 of the 42 hand-harvested crops. Of the 991 county-crop combinations, 171 required imputation.

The MLD method resulted in an estimate of 14,121 worker-seasons. Table 2 shows worker seasons by crop group, ranging from 1,629 worker-seasons (bush/vine/corn) to 5,638 worker-seasons (ground crops).

Discussion

The main objective of the study was to assess the feasibility of estimating hand-harvest crop worker-seasons (MLD) using publicly available data. Data were readily available as to which crops are hand-harvested in the state, state-specific worker hours, days customarily worked, season length for each crop, and hours required to harvest an acre.

One potential source of bias involved the use of an 8.8 hour workday as provided by the DOL dataset, which is acknowledged to be incomplete. Because data on the length of the workday are not available from farms that did not register with the DOL, it is not possible to contrast the length of their workday with that of the 438 farms that registered. Thus, while it is not possible to formally estimate the extent of non-response bias on this variable, we were unable to identify any reason why the two groups would differ. Because of the large sample size (438), there is little concern regarding the stability of this mean of 8.8 hours per day.

More problematic were the data on acres harvested. As described in the Methods section, imputation of missing harvest acreage was necessary for 21% (171/991) of the county-crop combinations. In addition, for orchard and vine crops, it was necessary to estimate all harvest acreage using a combination of production acreage and trees or vines of bearing age.

In light of the varying densities and heights of tree and vine crops, the possibility that harvested acres may not be the best parameter for estimating total hours required (THR) should be considered. Replacing this parameter with some other estimate of production, such as bushels or pounds, may prove beneficial. This would be true for any crop with variable planting densities and tree or plant size.

A third area for further research is the possibility of gathering MLD estimation factors (hours worked per week, hours needed to harvest one acre, days in season) by direct farm survey rather than by relying on expert opinion. A random telephone survey could

Table 2. Two estimates of temporary harvest worker-seasons in New York State, 2000: NYS Department of Labor registration (DOL) vs. estimated minimum labor demand (MLD).

	DOL	MLD	DOL/MLD (%)
Bush/vine/corn	656	1,629	40
Below ground	602	1,881	32
Ground	1,551	5,638	28
Orchard fruit	5,421	4,973	109
Total	8,230	14,121	

provide accurate data on these factors if farm employers currently keep this kind of information, and if they would be willing to provide it to researchers.

The resulting MLD estimate is nearly twice the DOL estimate. While the MLD method needs validation of the estimation factors, it does not appear to be subject to the main disadvantage of the DOL-based system; that is, it is not dependent on the participation of individual farms, and it excludes operations with less than five workers. For this reason, one would expect a production-based estimation method to result in a larger estimate than that of the DOL.

Conclusions

Currently, there is a need among health service providers and epidemiologists for reliable estimates of the temporary harvest worker population size. This would prove useful not only in estimating occupational injury risk, but also in planning for the provision of health and social services. The MLD, while not thoroughly tested or validated, is a promising new method that makes use of existing data to estimate this worker population by crop and county.

The main difficulties encountered were: the lack of data in certain rural counties, uncertainties relating to planting densities of trees and vines, and the need to impute missing data.

While the current analysis and MLD formula is specifically designed for field crop hand-harvest work, the general concept might be applied to other agricultural activities where the size of the underlying worker population is not known.

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Appendix 1: Calculation of Worker Seasons

The following example shows how to calculate worker-seasons for potatoes in Franklin County, New York, 1999. All data on the four required factors for these examples are taken from the 1997 Census of Agriculture (USDA, 1999) and the 2002-2003 Annual Bulletin: Fruit and Berries (USDA, 2003).

Total harvest acres = 736
 Hours to harvest one acre = 2
 Worker season length in days = 127.62
 Work day in hours = 8.8

Following the methodology described in the text, this yields:

THR = $736 \times 2 = 1472$
 THC = $127.62 \times 8.8 = 1123.1$
 MLD_{WS/crop} = $1472 / 1123.1$

Appendix 2: Imputation of Missing Production or Harvest Acreage

The following example involves imputation of missing production acreage for an orchard crop. The logic and procedure are identical for imputation of harvest acreage.

Given from published sources:

Published state total acreage for NYS = 60,250

Published sum of assigned individual New York county apple acreages = 56,586

Total number of apple farms in NYS missing apple acreage information = 50

Total number of apple farms in Franklin County = 3

Step 1. Calculate total production acreage not assigned at the county level:

$$\text{Total non-assigned production acres} = 60,250 - 56,586 = 3664$$

Step 2. Calculate average acreage on farms with missing acreage data:

$$\text{Average acreage} = 3,664 / 50 = 73.28$$

Step 3. Multiply average acreage per farm times the number of farms in Franklin County to obtain estimate of total missing acreage for Franklin County:

$$\text{Total missing acreage} = 73.28 \times 3 = 219.84$$

Appendix 3: Conversion of Production Acreage into Harvest Acreage

Step 1. Calculate harvest acreage proportion:

Given from published sources:

Acres of bearing-age apple trees in NYS = 55,000

Published state total acres for NYS = 60,250

$$\text{Harvest acreage proportion} = 55,000 / 60,250 = 0.913$$

Step 2. Calculate total harvest acres:

Given from step 1 and example in Appendix 2:

Harvest acreage proportion = 0.913

County total production acres = 219.84

$$\text{Franklin County total harvest acres} = 219.84 \times 0.913 = 200.7$$

Appendix 4: Total Harvest Season Hours, New York, 1997

Crop	Total Harvest Acres (1997)	Hours to Harvest One Acre	Total Hours in Season ^[a]
Apples	54,912	62.49	880.65
Asparagus	198	72.5	371.67
Berries	3,166	198.71	702.84
Broccoli	487	80.92	1866.26
Brussels sprouts	42	120	520.29
Cantaloupes	367	60	371.67
Cauliflower	565	76	1357.28
Chinese cabbage	324	96	517.01
Collards	99	92	993.75
Cucumbers	3,776	110	614.06
Dry onions	11,654	84.5	614.06
Eggplant	555	151.2	743.22
Endive	22	133	993.75
Escarole	35	75	633.40
Grapes	31,401	40	630.12
Green onions	287	220	614.06
Head cabbage	13,600	52	1728.94
Herbs	58	293	743.22
Hot peppers	53	159.8	554.22
Kale	45	180	993.75
Lettuce	1,132	95	993.75
Mixed vegetables	641	121.28	843.10
Mustard greens	62	178	993.75
Other vegetables	669	121.28	843.10
Parsley	44	293	492.81
Peaches	1,573	35.25	508.98
Pears	1,974	76	500.95
Plums/prunes	265 ^[b]	34	379.70
Potatoes	23,473	2	1123.03
Pumpkins	5,376	55.87	492.81
Radishes	630	367	1728.95
Raspberries	318	135	985.61
Rhubarb	12	120	880.65
Spinach	449	119.64	630.12
Squash	2,895	69.54	1106.86
Strawberries	1,528	355.13	242.39
Sweet cherries	740	218	250.42
Sweet corn	66,482	37	751.37
Sweet peppers	950	96.69	614.06
Tame blueberries	644	106	880.65
Tomatoes	3,284	145.03	864.47
Watermelons	61	53	371.67

^[a] For calculation purposes, this is equivalent to: (number of days in season) × (number of hours worked per day) given in the text.

^[b] For plums and prunes, acres of bearing age were not available. Tree proportion was used to impute harvest acreage.

