2016 AGRICULTURAL WORKFORCE

Agriculture economy
Agriculture labor market
Employment and earnings
H-2A and prevailing wages
Prevailing and normal or common practices

Employment Security Department
WASHINGTON STATE

Workforce Information and Technology Services
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2016 Agricultural Workforce Report

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Washington's agricultural economy stands apart

Agricultural activities have played a more significant role in Washington state than in the United States as a whole. During the last decade, agriculture in Washington state has accounted for a range of 0.81 to 1.07 percent of the state's Gross Domestic Product (GDP), which is about 0.2 to 0.3 percentage points greater than the national average. Likewise, the state's agricultural sector has been a greater source of employment compared to the nation. During the same period, the agricultural sector in Washington created a range of 1.89 to 2.27 percent of total covered employment (jobs which are covered under unemployment insurance), compared to 1.39 to 1.52 percent nationwide. Agriculture in Washington state also has higher productivity than the national average. From 2007 through 2015, Washington state's GDP per agricultural employee was greater than the national average by about $1,300.

Despite differences, it has been observed in Washington state and nationwide that agriculture's share of employment relative to the entire economy has been decreasing, while agriculture's share of GDP has remained the same.

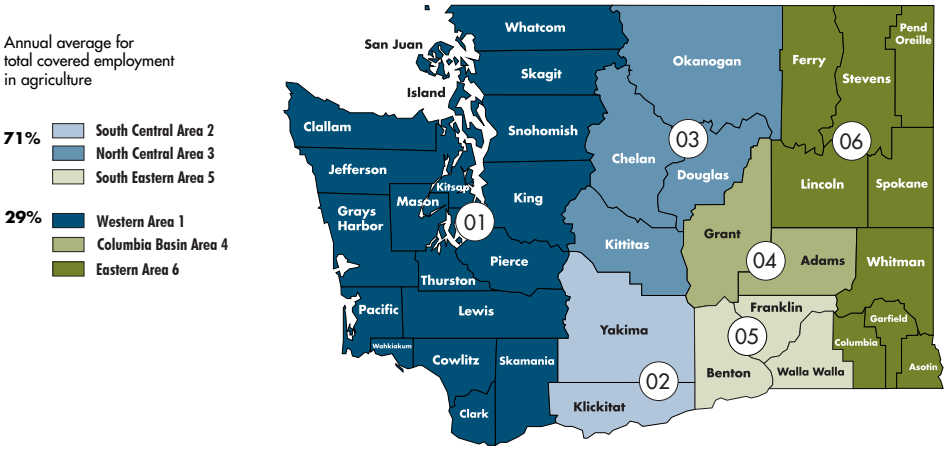
With respect to commodities, Washington state's agriculture is more dependent on fruit production relative to the national average, a commodity that requires more labor intensive production than other crops. In 2015, Washington state generated more than 70.2 percent of revenue from crop commodities whereas livestock and livestock products were major commodities for the nation. Furthermore, in Washington state, fruits and nuts created 36.3 percent of total agricultural revenue, which is more than five times the national average. In contrast, grain production accounts for 7.8 percent of total revenue in Washington compared to 25.6 percent in the nation.

Covered employment and wages in agriculture

The annual average for total covered agricultural employment in Washington grew 28.1 percent from 75,763 in 2007 to 97,068 in 2016, or approximately 3.1 percent annually. During this period, Washington's annual average for covered seasonal agricultural employment grew 20 percent from 28,907 in 2007 to 34,677 in 2016, or approximately 2.2 percent.

There are six agricultural reporting areas in Washington state. In 2016, three agricultural reporting areas, South Central Area 2, North Central Area 3 and South Eastern Area 5, accounted for 71 percent of the annual average total covered employment in agriculture. The remaining three areas, Western Area 1, Columbia Basin Area 4, and Eastern Area 6, produced 29 percent of the annual average total covered employment.

Agricultural reporting areas



On average, seasonal employment was about 36.3 percent of the state's covered agricultural employment during 2015 and 2016. It should be noted that this estimate is not directly comparable to those in the previous report due to changes in the estimation method. Changes in the estimates are briefly explained in the improvements section of this report, and the new method is described in *Appendix 2*.

From 2007 through 2016, Washington state's covered seasonal employment peaked at 40,012 in 2011 followed by a significant drop to 29,698 in 2012. Since then, it has undergone a steady increase, reaching 34,677 jobs in 2016.

In 2016, South Central Area 2 had the greatest amount of covered seasonal agricultural employment followed by North Central Area 3 and South Eastern Area 5. These areas had more covered agricultural seasonal jobs than the other agricultural areas due to larger covered agricultural employment in general and to their concentration of tree fruit production.

In 2016, apple orchards produced the greatest amount of total and seasonal covered agricultural employment. This industry accounted for 26.6 percent of total employment during 2016.

Employment dynamics in agriculture

For this report, we applied an approach, developed by U.S. Department of Agriculture economists to identify agricultural labor shortages, to Washington state employment data. Our analysis showed insufficient evidence of labor supply shortages for the state in 2016. Although there were some agricultural industries that experienced declining employment with rising wages, the changes in wages and employment were not substantial enough to conclusively identify a shortage using certain thresholds.

To measure job movement in agriculture, such as the employment transitions that migrant and seasonal farmworkers make, we analyzed the number of times workers changed jobs within the agricultural sector and between agriculture and other sectors. The analysis revealed that in 2016, the equivalent of about 20 percent of the workforce in agriculture moved from nonfarm jobs to agricultural jobs. We found that in 2016, agricultural employers hired 20,244 workers who had worked in nonfarm sectors in the prior quarter. At the same time, employers in nonfarm sectors hired 21,969 workers who had worked in the agricultural sector in the prior quarter.

Changing jobs was also associated with wage changes. Changing to an agricultural job was associated with a loss of average hourly wages of $1.75. Workers who changed from a nonfarm job to an agricultural job earned average hourly wages of $15.30 in their nonfarm jobs, compared to their average hourly agricultural wages of $13.55. We observed the opposite on workers who changed from an agricultural job to a nonfarm job. Changing to a nonfarm job was associated with a gain of average hourly wages of $1.45. Workers earned average hourly agricultural wages of $13.53 before they exited the sector, while they earned average hourly wages of $14.98 in their nonfarm jobs.

Even within agriculture there is more movement than in other sectors. In any given quarter of 2016, more than 40 percent of agricultural employees worked in an agricultural industry different from the agricultural industry in which they had worked in the previous quarter. For all other sectors, that number is considerably less, at 21.7 percent of employment.

Prevailing wages and employment practices in agriculture

In 2016, the prevailing wage rate for apple harvest ranged from a low of $20 per bin for Red Delicious apples to a high of $26 per bin for Golden apples. The prevailing wage for red cherry harvest was $3 per 15-pound bucket, while the prevailing wage for yellow cherry harvest was $6 per 20-pound lug. For Bartlett pear harvest, the prevailing wage was $22 per bin; for D'Anjou pears, it was $26.50. The prevailing wage for apricot harvest was $12 per hour, and for hop harvest, $14 per hour. Asparagus and blueberry harvest prevailing wages were both by the pound, with asparagus harvest at $0.27 per pound and blueberry harvest at $0.50 per pound. For apple tree thinning, prevailing wages ranged from $12.69 per hour for Honeycrisp and Red Delicious to $12.75 per hour for Fuji.

Employer responses to the 2016 Agricultural Peak Employment Wage and Practice Employer Survey indicate that it is not a prevailing practice to provide housing to non-working family members of workers for any of the commodity activities included in the survey. Similarly, we did not have any occurrences by commodity activity where minimum productivity standards or experience requirements were a normal and common practice.

Data sources

We use four different data sources in this report. Estimates for a given variable change according to the data source, though overall trends are consistent among all the sources cited.

The first data source is the **Quarterly Census of Employment and Wages** (QCEW), which the U.S. Bureau of Labor Statistics (BLS) produces in cooperation with the Washington State Employment Security Department (ESD). QCEW contains monthly industry employment and quarterly wage data by worksite (employer location) from quarterly tax reports provided by employers for workers covered by the unemployment insurance (UI) system. Covered employment accounts for more than 85 percent of total employment in the state and includes all hired agricultural labor except small farm operators, non-resident aliens, independent contractors and corporate officers.

The **UI Wage File** is the second source used for this report. This source includes quarterly wage and hour data for all individual workers covered by the UI system that employers report to ESD in a given calendar year. Unlike QCEW data, employers report wage, hours and employment information in the UI Wage File by firm, rather than by worksite. Consequently, wages reported by firms with multiple worksites can include information for workers who do not work at the physical location listed in the UI Wage File.

Gross Domestic Product and Personal Income from the U.S. Bureau of Economic Analysis (BEA) are the third data source. BEA data for farm employment are different from QCEW and the UI Wage File. BEA farm employment data contain farm output characteristics and are estimates of the number of employees, rather than jobs as in QCEW and UI.

The fourth source is the **2016 Agricultural Peak Employment Wage and Practice Employer Survey** conducted by ESD and the University of Washington's Survey Research Division. The survey results include wage rates and employment practices that employers offer to U.S. seasonal, local or migrant workers who perform activities for which at least one employer filed a job order to hire foreign workers through the U.S. Department of Labor's *Temporary Agricultural Foreign Labor Certification Program* (H-2A).

For more information, see *Appendix 1*.

Improvements in the agricultural workforce report

In this report, we introduce new sections and estimation methods. Because of these changes, we present estimates for 2016 and the previous 10 years to avoid comparing estimates in this report to previous reports.

Innovations in measuring seasonal and non-seasonal employment

We introduce an improved method that uses econometric models and QCEW data to estimate seasonal and non-seasonal employment. Using econometric models, we are able to break down seasonal employment data without relying on a manual breakpoint by hours worked. See *Appendix 2* for more detail.

This improved method is consistent with our methods used to develop industry and occupational employment projections. Although we do not develop agricultural industry or occupational employment projections in this report, the same econometric models and data allow us to identify annual seasonal employment based on historical variable annual employment since 1990. Using industry-specific models and historical data instead of a fixed hourly threshold allows us to identify industry-specific seasonal employment. Also, it helps reduce misidentification of non-seasonal jobs as seasonal jobs that are in fact worker turnover.

Seasonal and non-seasonal employment changed significantly in this report compared to the *2015 Agricultural Workforce* report due to the change of the definition of seasonal workers. In the *2015 Agricultural Workforce* report, we defined seasonal workers as those who worked less than 1,500 hours during the year in an agricultural industry. For this report, we do not define seasonal jobs based on number of hours worked; instead, each econometric model used for each industry identifies seasonal employment as changes that are random, recur each calendar year, or are attributed to business cycles or specific events.

Despite the significant changes in seasonal and non-seasonal employment compared to the *2015 Agricultural Workforce* report, total agricultural employment was not drastically affected by the method change. Minor changes in total agricultural employment between this report and the *2015 Agricultural Workforce* report are due to changes in the definition of the agricultural sector. For example, in the 2015 report, we included employment in the forest nurseries and gathering of forest products industry in total agricultural employment, but not in this report.

Looking at both reports, 2015 and 2016, seasonal and non-seasonal employment appear reversed. In the 2015 report, seasonal employment was larger than non-seasonal employment. In this report, however, seasonal employment is smaller than non-seasonal for all years reported. For example, in the *2015 Agricultural Workforce* report we reported that seasonal employment in 2014 was 53,667 as opposed to 32,210 seasonal

employment in this report. The majority of the difference might be attributed to the change in definition and estimation method for seasonal employment, while the rest of the difference is likely attributed to changes in the definition of the agricultural sector.

Advancements in agricultural wage estimations

We present average and median hourly wages by industry at the state level and average annual wages at the state and agricultural reporting area levels. This year we do not calculate median hourly wage rates by agricultural reporting areas to avoid assigning employers' UI reporting addresses to workers' actual worksites. Tax records include quarterly wages and hours by firm rather than by worksite. Although the UI Wage File includes the firm's physical location, this location is not always the location where employees work – particularly workers of firms with multiple worksites.

Washington's agricultural economy stands apart

In this section, we discuss the differences and similarities of Washington state agriculture compared to the United States as a whole.

Figure 1 shows the large impact agriculture has in Washington's economy, compared to the nation, and compares the U.S. and Washington state economic indicators from 2007 through 2015. The state's agricultural activity, employment and productivity contribute more to Washington's economy than the nation's agricultural industry share. Agricultural activities generally play a more significant role in Washington state. For 2007 through 2015, agricultural activities in Washington have accounted for a range of 0.81 to 1.07 percent of the state's Gross Domestic Product (GDP), about 0.2 to 0.3 percentage points greater than the national average. Likewise, agriculture in the state has been a greater source of employment compared to the nation. For the same period, the agricultural sector in Washington created a range of 1.89 to 2.27 percent of total covered employment, compared to 1.39 to 1.52 percent nationwide.

Agriculture in Washington state also has higher productivity than the national average. For six of the nine years, Washington's GDP per agricultural employee was greater than the national average. On average, GDP per agricultural employee in Washington was about $1,300 greater than the U.S.

Figure 1. Major economic indicators for agriculture
U.S. and Washington state, 2007 through 2015*
Source: U.S. Bureau of Economic Analysis (BEA)

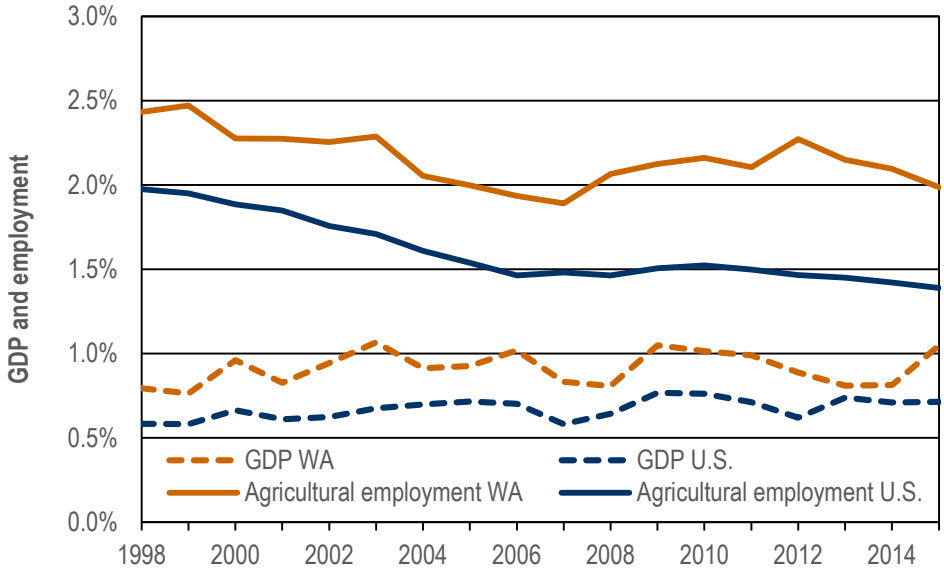
Economic indicator	Area	2007	2008	2009	2010	2011	2012	2013	2014	2015
GDP share	WA	0.83%	0.81%	1.05%	1.01%	0.99%	0.89%	0.81%	0.81%	1.07%
	U.S.	0.58%	0.64%	0.77%	0.76%	0.71%	0.62%	0.74%	0.71%	0.75%
Total employment	WA	1.89%	2.07%	2.12%	2.16%	2.11%	2.27%	2.15%	2.10%	1.99%
	U.S.	1.48%	1.46%	1.51%	1.52%	1.50%	1.46%	1.45%	1.42%	1.39%
GDP per employee (thousands of dollars)	WA	40.1	35.6	45	44.2	44.1	36.9	35.6	36.8	50.2
	U.S.	32.3	36	41.9	42.3	40.1	35.7	42.9	42.1	43.5

*2016 data were not available as of January 2018.

Agricultural activities play a more significant role in Washington state than in the nation.

Figure 2 illustrates both the state's and the nation's trends of total employment and GDP from 1998 through 2015 (for the full data, see www.bea.gov/iTable/index_regional.cfm). Despite declining employment shares in agriculture both in Washington state and in the U.S., productivity as measured by GDP has remained largely stable, suggesting productivity enhancements. Productivity enhancements may include innovations such as mechanization, and improved cultivation methods and varieties.

Figure 2. Trends of GDP and employment share in agriculture
U.S. and Washington state, 1998 through 2015
Source: U.S. Bureau of Economic Analysis (BEA)



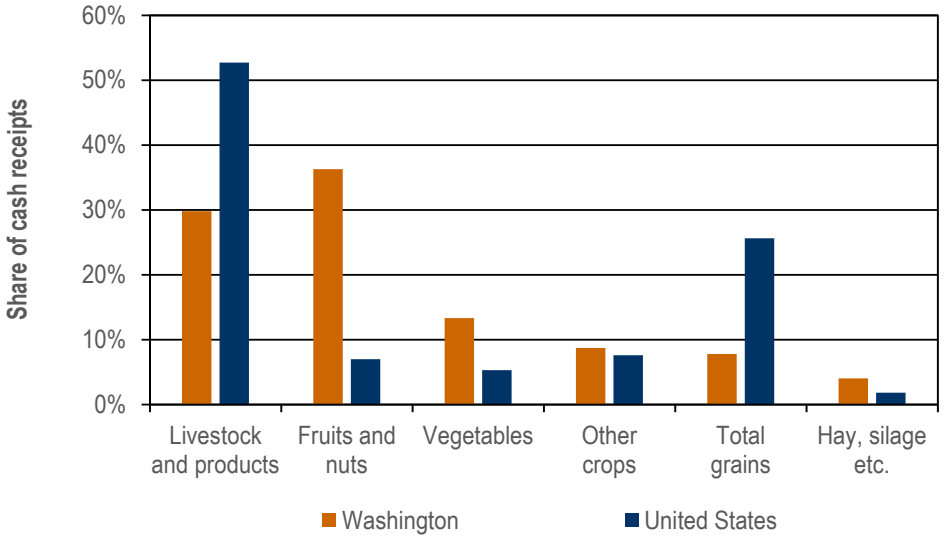
A declining trend of total employment's share of agriculture combined with a largely stable GDP may suggest productivity enhancements in Washington state and in the nation.

Figure 3 illustrates the structure of the agricultural economy in Washington state and compares it with the nation using 2015 data. Relative to the national average and based on gross revenue of products as measured by cash receipts,[1] Washington state's agriculture is characterized by its significant dependence on fruit production, which requires a more labor intensive production process than other crops.

Washington state generated 70.1 percent of cash receipts from crop commodities combined whereas livestock and livestock products generated the larger share of cash receipts for the nation. Furthermore, in Washington state fruits and nuts created 36.3 percent of total cash receipts in agriculture, which is more than five times the national share. In contrast, grain production accounts for a substantially smaller portion of total cash receipts in Washington (7.8 percent) than in the nation (25.6 percent). Washington's other shares of cash receipts were vegetables (13.3 percent), other crops (8.7 percent) and hay and silage, etc., at 4 percent.

[1] Cash receipts consist of the gross revenue received by farmers from the sale of crops, livestock and livestock products, and of the value of defaulted loans made by the Commodity Credit Corporation and secured by crops.

Figure 3. Structure of agricultural economy based on cash receipts*
U.S. and Washington state, 2015
Source: U.S. Bureau of Economic Analysis (BEA) - Farm Income and Expenses



* Livestock and products include meat animals such as cattle and calves, hogs and pigs, sheep and lambs, poultry and poultry products (including eggs), and dairy products. Also included are horses, bees, animal aquaculture and other miscellaneous animal species raised on agricultural operations.

Total grains include corn, oats, sorghum, wheat, soybeans and other grains such as buckwheat, rice, rye, barley, flaxseed, tung nuts, sunflower, safflower, sesame, miscellaneous oil crops, dry peas, beans and popcorn.

Hay, silage, etc., include hay, silage, alfalfa, clover, bentgrass, bluegrass-Kentucky, fescue, orchard grass, rye grass and sorghum sudan.

Vegetables indicate vegetables grown in the open except dry beans and dry peas.

Fruits and nuts include citrus fruits, noncitrus fruits such as apples and grapes, berries and tree nuts.

Other crops include peanuts, sugar crops, hops and mint.

Washington agricultural economy relies more on fruits and nuts, vegetables and hay compared to the nation, which relies more on livestock and products and grains.

Covered employment and wages in agriculture

This section shows trends in covered employment and wages for agricultural workers in Washington state and its agricultural reporting areas. It covers changes in total employment, regional and seasonal employment patterns, and employment patterns in different agricultural industries. In addition, it presents median hourly wages and average annual wages by industry and agricultural reporting area. Note that the data presented in this section is only for agricultural workers covered by the unemployment insurance (UI) system, which accounts for an estimated 83.4 percent of total agricultural employment.[2]

Covered employment across agricultural reporting areas

Figure 4 shows total covered agricultural employment statewide and by agricultural reporting area for the top three industries from 2007 through 2016. (See *Appendix 6* for a map of the agricultural reporting areas.) *Figure 5* illustrates trends of total covered agricultural employment for each of the six agricultural reporting areas.

In Washington state, total covered employment in agriculture has grown almost every year from 2007 through 2016, with the exception of 2009 to 2010 and 2012 to 2013. Agricultural employment has grown from an annual average of 75,763 jobs in 2007 to an annual average of 97,068 jobs in 2016. The largest agricultural area measured by employment is South Central Area 2, followed by North Central Area 3 and South Eastern Area 5. In 2016, South Central Area 2 accounted for a total of 32,714 jobs, with North Central Area 3 at 19,763 and South Eastern Area 5 at 16,042. Western Area 1 had 13,756 jobs, whereas Columbia Basin Area 4 had 12,308 and Eastern Area 6 had only 2,480.

Tree fruit production is prominent in Washington state. In 2016, apple orchards was the dominant industry in the state as a whole (25,803 jobs) and in four agricultural reporting areas: South Central Area 2 (8,761 jobs), North Central Area 3 (8,380), South Eastern Area 5 (4,858) and Columbia Basin Area 4 (3,715). Combined with postharvest crop activities (except cotton ginning) and other noncitrus fruit farming, these top three industries accounted for 54,610 jobs.[3]

[2] Data sources: USDA 2012 Census of Agriculture Volume 1, Chapter 2: State Level Data. Table 45. Selected Operation and Operator Characteristics: 2012 and 2007. https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_US_State_Level/st99_2_045_045.pdf. Washington state covered employment (QCEW) – 2012 annual average covered employment in agriculture.

[3] Other noncitrus fruit farming includes fruits such as apricots, cherries, nectarines, peaches, pears, plums, prunes and quince. Postharvest crop activities (except cotton ginning) includes activities such as sorting, grading, cleaning and packing of fruits and vegetables.

Two industries went through significant expansion over the last 10 years: other food crops grown under cover in Western Area 1 (from 46 jobs in 2007 to 2,285 in 2016) and farm labor contractors and crew leaders in South Eastern Area 5 (from 156 jobs in 2007 to 1,697 in 2016). Though other food crops grown under cover in Eastern Area 6 experienced substantial growth, its relatively short growth history prevents conclusions about long-term trends.

From 2015 to 2016, state total covered agricultural employment increased by 2,075 jobs. Out of the six agricultural reporting areas, three areas (Western Area 1, South Central Area 2 and Eastern Area 6) experienced an increase in the number of jobs while the other three experienced a decline. The greatest increase in number of jobs occurred in Western Area 1, with an increase of 1,512 jobs.

In Western Area 1, the industries with the highest covered employment levels were berry (except strawberry) farming, other food crops grown under cover, and nursery and tree production. Of the top three industries, employment in other food crops grown under cover doubled from 2015 to 2016 while the other two experienced more moderate changes.

In South Central Area 2, employment in all of the top three industries declined: apple orchards declined from 8,905 to 8,761, postharvest crop activities (except cotton ginning) declined from 7,619 to 7,499 and other noncitrus fruit farming declined from 5,965 to 5,945. However, total covered agricultural employment in the area experienced growth.

Of the top three industries (apple orchards, other noncitrus fruit farming and postharvest crop activities) in North Central Area 3, only apple orchards experienced growth in covered employment from 2015 to 2016.

In Columbia Basin Area 4, total agricultural employment for the area and each of the top three industries (apple orchards, postharvest crop activities and other noncitrus fruit farming) decreased from 2015 to 2016. In particular, the decrease in employment in the apple orchards industry was quite large. Employment decreased from 4,313 to 3,715.

Total covered agricultural employment in South Eastern Area 5 experienced a slight drop from 16,216 jobs in 2015 to 16,042 jobs in 2016. It appears that the drop was led by a decrease in the apple orchards industry, which decreased by 283 jobs.

In Eastern Area 6, the other food crops grown under cover industry first appeared in 2014 and has since gone through significant growth. As a result, in 2016 this industry produced 951 jobs in the area and was the biggest source of agricultural employment.

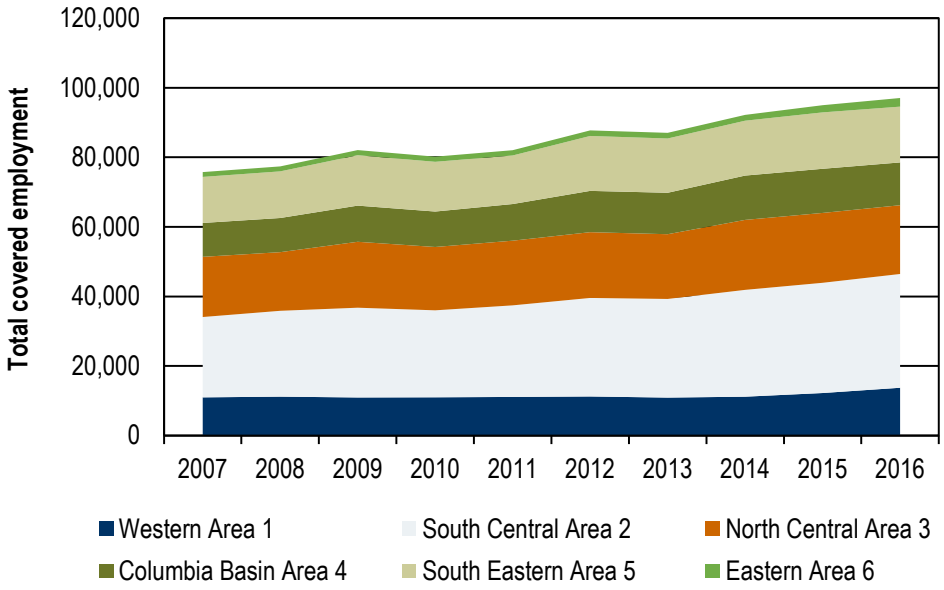
Figure 4. Covered employment in the agricultural sector and in the top three agricultural industries
Washington state and agricultural reporting areas,* 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Industry by area	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
State										
Total	**75,763**	**77,400**	**82,090**	**80,200**	**82,056**	**87,759**	**87,047**	**92,208**	**94,993**	**97,068**
Apple orchards	20,841	21,859	23,851	24,135	23,918	26,393	25,251	27,257	26,730	25,803
Postharvest crop activities (except cotton ginning)	12,030	11,656	13,038	12,408	12,920	13,857	14,335	14,893	15,187	14,754
Other noncitrus fruit farming	12,613	12,215	13,735	12,601	12,470	13,446	13,088	14,423	14,749	14,053
Western Area 1										
Total	**10,995**	**11,205**	**10,966**	**11,014**	**11,118**	**11,255**	**10,931**	**11,190**	**12,244**	**13,756**
Berry farming (except strawberry)	1,865	2,154	2,160	2,208	2,278	2,442	2,182	2,221	2,396	2,623
Other food crops grown under cover	46	57	69	75	104	91	83	255	1,059	2,285
Nursery and tree production	2,234	2,249	2,075	1,975	1,950	1,869	1,819	1,807	1,780	1,677
South Central Area 2										
Total	**23,102**	**24,677**	**25,808**	**25,008**	**26,330**	**28,326**	**28,359**	**30,712**	**31,691**	**32,714**
Apple orchards	6,101	6,423	7,048	7,114	7,717	8,464	8,048	8,844	8,905	8,761
Postharvest crop activities (except cotton ginning)	5,436	5,466	6,012	5,889	6,331	6,910	7,158	7,641	7,619	7,499
Other noncitrus fruit farming	4,322	4,435	4,915	4,515	4,364	4,818	4,826	5,605	5,965	5,945
North Central Area 3										
Total	**17,302**	**16,859**	**18,950**	**18,209**	**18,595**	**18,904**	**18,611**	**20,116**	**20,086**	**19,763**
Apple orchards	7,347	7,517	8,452	8,524	8,132	8,119	7,760	8,705	8,288	8,380
Other noncitrus fruit farming	5,103	4,814	5,372	4,834	4,970	5,161	5,163	5,406	5,588	5,448
Postharvest crop activities (except cotton ginning)	3,767	3,471	4,086	3,860	3,946	3,935	4,116	4,186	4,448	4,259
Columbia Basin Area 4										
Total	**9,741**	**9,822**	**10,399**	**10,188**	**10,535**	**11,874**	**11,915**	**12,743**	**12,690**	**12,308**
Apple orchards	3,195	3,321	3,727	3,546	3,438	4,474	4,149	4,499	4,313	3,715
Postharvest crop activities (except cotton ginning)	948	937	981	816	908	1,121	1,284	1,280	1,342	1,290
Other noncitrus fruit farming	1,303	1,260	1,391	1,304	1,362	1,270	1,235	1,362	1,267	1,194
South Eastern Area 5										
Total	**13,238**	**13,407**	**14,495**	**14,301**	**13,962**	**15,791**	**15,607**	**15,778**	**16,216**	**16,042**
Apple orchards	4,094	4,528	4,571	4,903	4,558	5,247	5,204	5,118	5,141	4,858
Grape vineyards	1,476	1,518	1,639	1,545	1,611	1,733	1,862	1,713	1,764	1,890
Farm labor contractors and crew leaders	156	228	593	521	723	804	986	1,230	1,569	1,697
Eastern Area 6										
Total	**1,383**	**1,428**	**1,470**	**1,477**	**1,515**	**1,599**	**1,621**	**1,669**	**2,065**	**2,480**
Other food crops grown under cover	0	0	0	0	0	0	0	60	482	951
Wheat farming	585	609	620	627	658	686	663	612	566	534
Floriculture production	151	150	157	158	158	160	160	157	166	155

*The summation of employment in the six agricultural reporting areas does not always add up to state total agricultural employment. This is because location codes for some employers are unknown. The difference ranged from 0 to 10.

In 2016, apple orchards was the dominant industry in the state and in four agricultural reporting areas: South Central Area 2, North Central Area 3, Columbia Basin Area 4 and South Eastern Area 5.

Figure 5. Total covered agricultural employment in agricultural reporting areas
Washington state, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

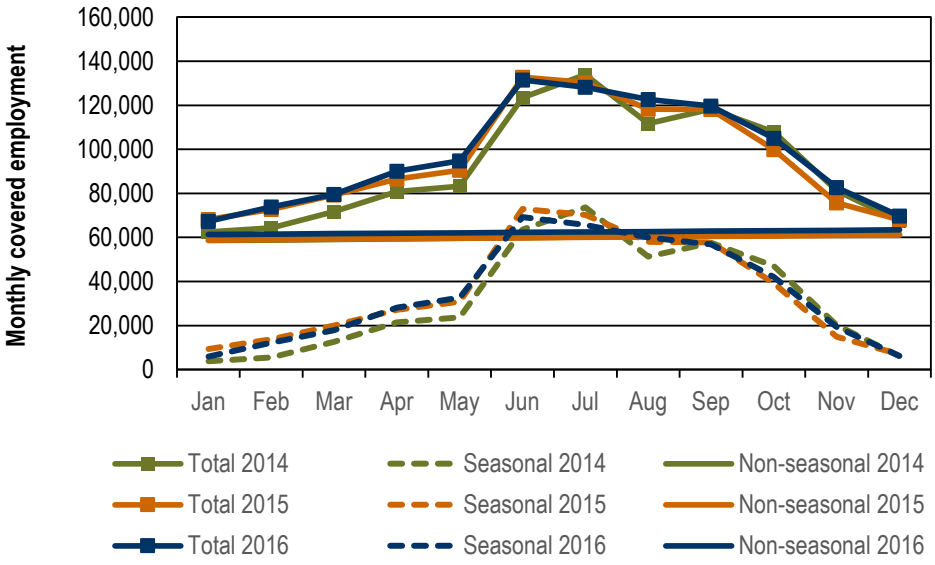


South Central Area 2 contributed the largest number of total covered agricultural jobs during 2016 followed by North Central Area 3 and South Eastern Area 5. These three areas accounted for more than 70 percent of total covered agricultural employment in Washington state in 2016.

Estimated covered seasonal agricultural employment

Figure 6 shows monthly seasonal, non-seasonal and total agricultural employment from January 2014 through December 2016. The figure indicates that variations in total agricultural employment during a year are mostly attributed to variations in seasonal employment. While non-seasonal employment was stable, remaining around 60,000 jobs throughout a year, seasonal jobs ranged from below five thousand to more than 70,000. During the period, seasonal employment was typically highest from June through October (over 40,000).

Figure 6. Monthly seasonal, non-seasonal and total employment in agriculture
Washington state, 2014 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW



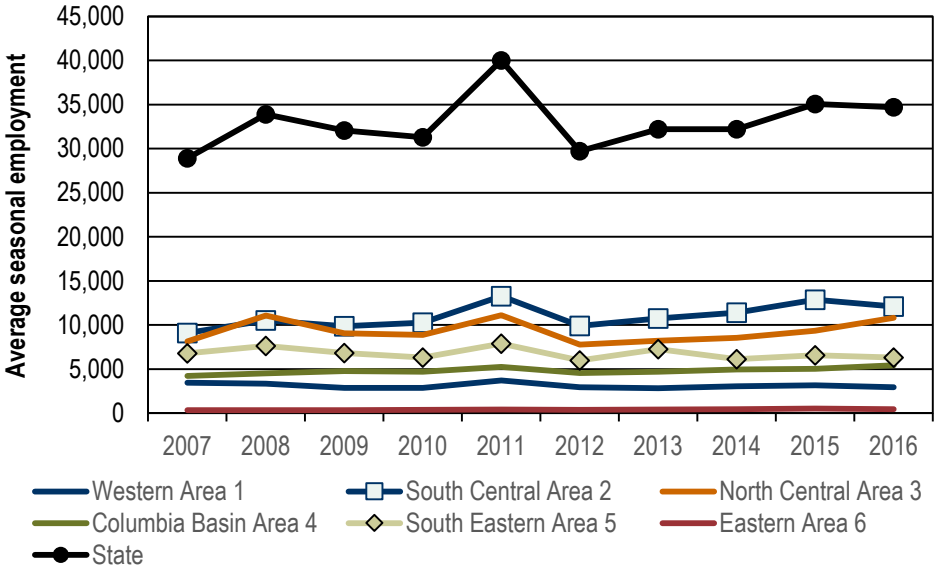
During the period, seasonal employment in agriculture was typically highest from June through October (over 40,000).

Seasonal employment by agricultural reporting area

Figure 7 shows annual average covered seasonal employment by agricultural reporting area from 2007 through 2016. During this time, Washington state's covered seasonal employment peaked in 2011 (40,012) followed by a significant drop in 2012 (29,697). Since then, it has undergone a steady increase through 2016.

In 2016, South Central Area 2 had the highest covered seasonal employment (12,082 jobs) followed by North Central Area 3 and South Eastern Area 5. These areas have more covered seasonal jobs than the other areas thanks to larger total covered agricultural employment and to their concentration of tree fruit production, which often requires more manual labor during the production process. The latter can be seen in *Figure 8*, which charts the percentage of seasonal employment relative to total employment. Four central agricultural reporting areas (South Central Area 2, North Central Area 3, Columbia Basin Area 4 and South Eastern Area 5) have a higher percentage of seasonal employment than the other two areas (Western Area 1 and Eastern Area 6), thanks to their higher concentration of tree fruit production. In 2016, seasonal employment accounted for more than 50 percent of total covered agricultural employment in North Central Area 3.

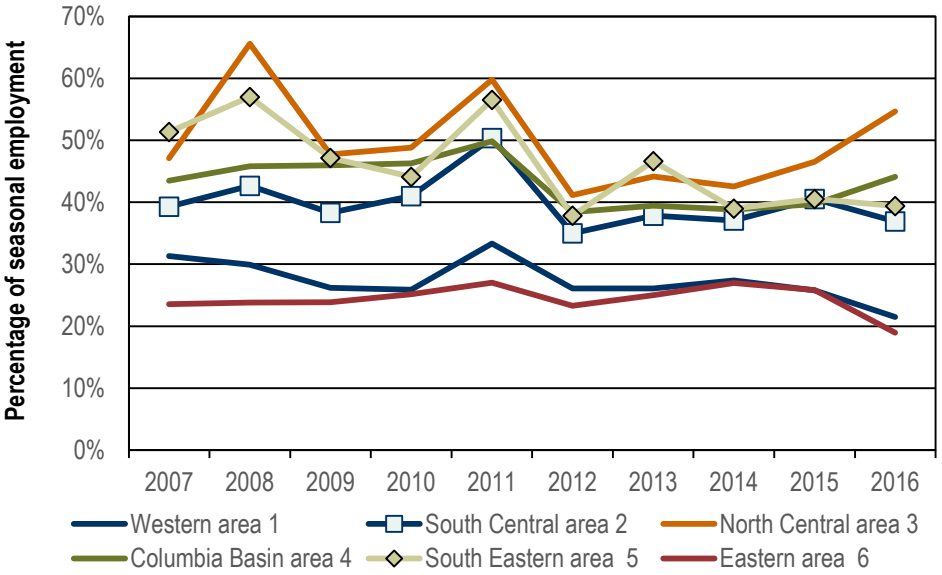
Figure 7. Average covered seasonal employment in agriculture*
Washington state, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW



* Summing the areas' seasonal agricultural employment will not add up to state total seasonal agricultural employment. This is because seasonal adjustments are based on statistical models that depend on levels of aggregation.

The state's seasonal employment in agriculture peaked in 2011, dipped in 2012 and then went through a moderate increase.

Figure 8. Percentage of covered seasonal employment in agriculture
Washington state, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

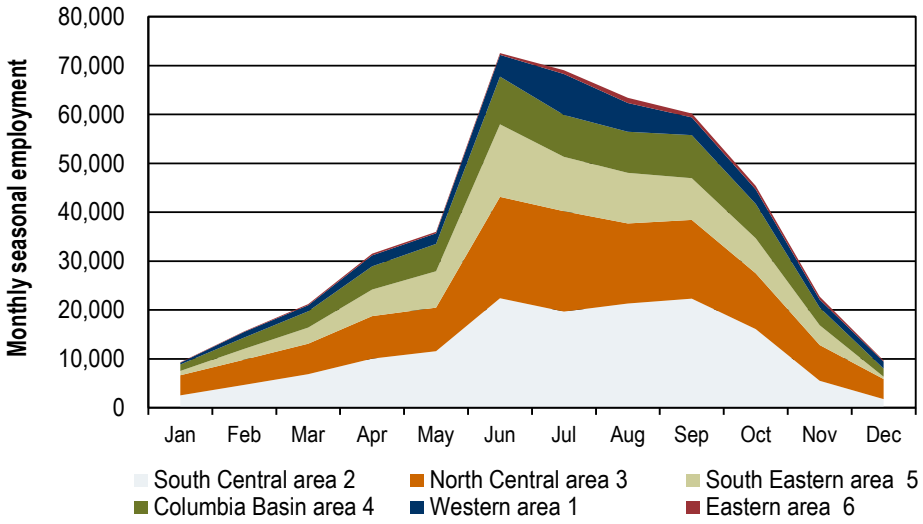


Four central agricultural reporting areas with higher concentration of tree fruit production have higher percentages of seasonal agricultural employment than the other two areas.

Figure 9 shows monthly covered seasonal employment by agricultural reporting area for 2016. In general, seasonal employment peaked in June, remained high until October, and was the lowest in January and December.

By agricultural reporting area, seasonal employment peaked in June in these four areas: South Central Area 2, North Central Area 3, Columbia Basin Area 4 and South Eastern Area 5. Western Area 1 and Eastern Area 6 had their peak in July and August, respectively. The area that showed the biggest gap between the highest and the lowest seasonal employment was South Eastern Area 5 with employment in June approximately 30 times larger than that in December.

Figure 9. Monthly covered seasonal agricultural employment by agricultural reporting area*
Washington state, January 2016 through December 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW



* The number of seasonal employment in agriculture, measured at the state level is not the same as the summation of seasonal agricultural employment across agricultural reporting areas. This is because statistical estimation for seasonality depends on levels of aggregation.

Seasonal employment in agriculture was significantly larger from June through October.

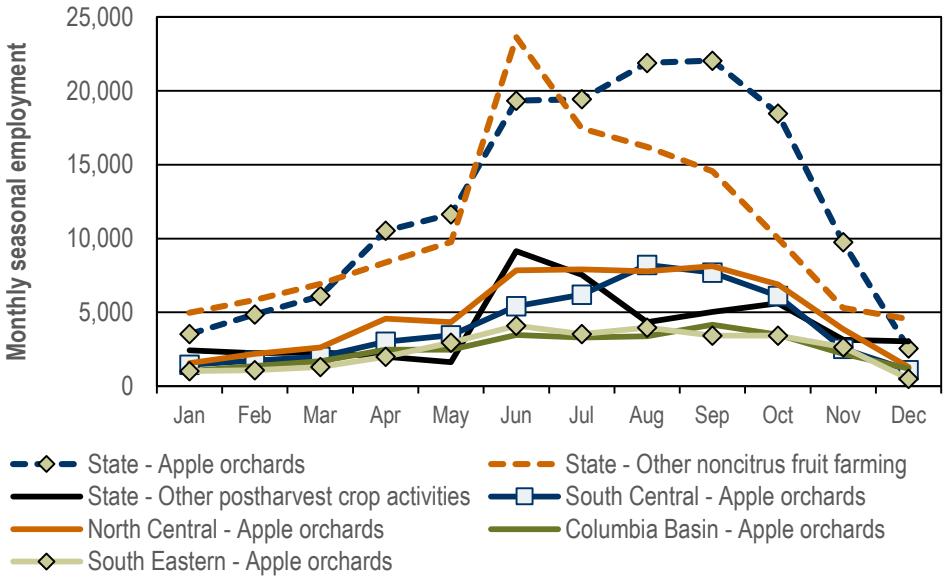
Seasonal agricultural employment by industry

Figure 10 shows seasonal employment during 2016 for selected agricultural industries. It also shows the top three industries for the state and the top industry for the four largest agricultural reporting areas in terms of total covered agricultural employment. Western Area 1 and Eastern Area 6 are omitted due to their small amount of seasonal employment in these industries.

At the state level, apple orchards and other noncitrus fruit farming industries showed large variation in seasonal employment during the year, contributing the most to the seasonality in total covered agricultural employment illustrated in *Figure 10*. Though similar patterns were observed in the postharvest crop activities industry, the variation was more moderate.

Apple orchards is the top industry in South Central Area 2, North Central Area 3, Columbia Basin Area 4 and South Eastern Area 5. The monthly seasonal employment of the peak season for this industry (June through October) is two to three times greater than that in the off-peak season in these areas. In the central areas, fluctuation was the biggest in South Central Area 2 and the least in Columbia Basin Area 4.

Figure 10. Monthly covered seasonal employment by select agricultural industries Washington state and agricultural reporting areas*, January 2016 through December 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW



* Western Area 1 and Eastern Area 6 are omitted due to their small amount of seasonal employment in these industries.

Apple orchards showed large variation in seasonal employment in 2016.

Wages for covered agricultural employment

Average annual agricultural wages across agricultural regions

Figures 11, 12 and *13* provide average annual wages from 2007 through 2016 for the state and its six agricultural reporting areas. All wage values are inflated to their 2016 values using the BLS Employment Cost Index (ECI).

Despite wages declining during the economic crisis of 2009,[4] over the last 10 years average annual agricultural wages in Washington state grew from $24,196 to $27,288. As shown in *Figure 13*, trends of wages over time are generally similar across agricultural reporting areas except for Eastern Area 6. The wages in Eastern Area 6 increased in 2016 after a significant drop from 2013 through 2015. Eastern Area 6 was unique in that its average annual wages continued to grow even when wages were decreasing throughout the rest of the state during the economic crisis.

[4] For more information, see National Bureau of Economic Research.

State average annual wages in 2016 were $27,288. Four areas had average annual wages greater than the state average: Western Area 1, South Central Area 2, Columbia Basin Area 4 and South Eastern Area 5. Two areas were lower than the state average: North Central Area 3 and Eastern Area 6. From 2015 to 2016, Washington's average annual wages in agriculture increased from $26,685 to $27,288 as a result of the increase in wages in all agricultural areas, except for Western Area 1 where wages remained about the same (*Figures 11* and *12*).

Figure 13 shows that in 2015 Eastern Area 6's average annual wage trend appears to be moving in the same direction as the state's, as it did from 2010 through 2013.

In Western Area 1, average annual wages for total covered agricultural employment remained almost the same from 2015 to 2016, in contrast with the growth of the average annual wages in the rest of the state. This reinforces the observation in *Figure 13* where the gap between average annual wages in Western Area 1 and average annual wages of the state has become smaller.

The industries with the highest covered employment levels in Western Area 1 were berry (except strawberry) farming, other food crops grown under cover, and nursery and tree production. In 2016, nursery and tree production had the highest average annual wages of the three averaging $29,069, and berry (except strawberry) farming had the lowest at $24,889.

In South Central Area 2, average annual wages grew from $27,867 in 2015 to $28,551 in 2016. Of the top three industries with the highest total covered agricultural employment, apple orchards, postharvest crop activities and other noncitrus fruit farming, postharvest crop activities had the highest average annual wages in 2016 of $31,837. Lowest average annual wages among the top three industries was in other noncitrus fruit farming at $23,933.

Average annual wages in North Central Area 3 were low compared to other areas and the state average. The industries with the highest total covered agricultural employment levels were apple orchards, other noncitrus fruit farming and postharvest crop activities. Apple orchards experienced a slight drop in average annual wages while the other noncitrus fruit farming and postharvest crop activities experienced significant increases in average annual wages from 2015 to 2016. The lowest average annual wages among the top three industries in terms of covered employment were in the other noncitrus fruit farming industry at $21,637 (*Figure 11*).

Figure 11. Average annual wages in the agricultural sector and top agricultural industries, adjusted to 2016 prices*
Washington state and Western Area 1, South Central Area 2 and North Central Area 3, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Industry by area	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
State										
Total	**$24,196**	**$24,448**	**$23,965**	**$23,527**	**$24,527**	**$25,143**	**$25,601**	**$26,392**	**$26,685**	**$27,288**
Apple orchards	$20,838	$20,926	$20,281	$19,661	$20,968	$21,992	$22,385	$23,448	$24,375	$24,703
Postharvest crop activities (except cotton ginning)	$27,864	$27,924	$28,354	$27,014	$27,822	$28,931	$29,314	$30,411	$30,276	$31,186
Other noncitrus fruit farming	$18,385	$18,784	$18,204	$17,907	$19,298	$20,157	$20,220	$21,239	$21,163	$22,388
Western Area 1										
Total	**$27,524**	**$27,166**	**$26,950**	**$26,824**	**$27,103**	**$27,278**	**$28,116**	**$28,706**	**$28,489**	**$28,492**
Berry farming (except strawberry)	$22,538	$20,094	$21,174	$21,209	$21,579	$21,876	$24,278	$25,148	$24,917	$24,889
Other food crops grown under cover	$25,967	$22,607	$24,143	$25,084	$28,090	$28,343	$26,758	$29,442	$27,301	$27,517
Nursery and tree production	$27,825	$26,912	$26,137	$26,504	$26,483	$27,545	$28,232	$29,081	$29,034	$29,069
South Central Area 2										
Total	**$24,652**	**$24,862**	**$24,834**	**$24,448**	**$25,193**	**$26,214**	**$26,778**	**$27,653**	**$27,867**	**$28,551**
Apple orchards	$21,450	$21,368	$21,864	$21,517	$22,355	$23,155	$23,828	$25,094	$25,602	$26,432
Postharvest crop activities (except cotton ginning)	$28,976	$28,518	$29,214	$27,953	$28,272	$29,934	$30,556	$31,210	$31,359	$31,837
Other noncitrus fruit farming	$20,363	$20,007	$18,892	$19,625	$20,645	$22,121	$21,646	$23,239	$22,764	$23,933
North Central Area 3										
Total	**$21,021**	**$21,179**	**$20,993**	**$19,656**	**$21,089**	**$21,614**	**$22,172**	**$22,499**	**$23,076**	**$23,898**
Apple orchards	$19,709	$19,832	$19,267	$17,871	$19,415	$19,932	$20,623	$20,691	$21,897	$21,828
Other noncitrus fruit farming	$17,488	$18,241	$17,905	$17,251	$18,945	$19,529	$19,903	$20,452	$20,494	$21,637
Postharvest crop activities (except cotton ginning)	$27,607	$27,504	$28,067	$25,860	$27,493	$28,213	$28,100	$29,788	$29,082	$30,552

* Wages were adjusted to current prices in 2016 using the ECI price index for construction, extraction, farming, fishing, and forestry developed and used by BLS for wage adjustments.

For the last 10 years, the average wages for agriculture in Washington state grew from $24,196 to $27,288.

Average annual wages increased from $27,152 in 2015 to $27,689 in 2016 in the Columbia Basin Area 4. The highest average wages in 2016 in an agricultural industry of this agricultural reporting area were $28,449. These wages were reported in the postharvest crop activities industry. The industry with the lowest average wages in 2016 among the top three industries was in apple orchards at $24,641.

In South Eastern Area 5 average annual wages increased from $27,435 in 2015 to $27,946 in 2016. The apple orchards industry had the highest average annual wages in 2016 of $26,692. The average annual wages in the farm labor contractors and crew leaders industry were $20,243. This is the lowest among the top three industries in all agricultural reporting areas.

Following North Central Area 3, Eastern Area 6's average annual wages of $24,713 were the second lowest in 2016 among the six agricultural reporting areas. However, average annual wages increased from $24,196 in 2015. Of the top three industries, wheat farming had the highest average annual wages in 2016 of $28,620. The lowest average annual wages among the top three industries were $22,240, which were reported

in other food crops grown under cover. From 2014 to 2016, average annual wages in other food crops grown under cover decreased from $31,776 to $22,240 while employment in the same industry increased sharply from 60 in 2014 to 951 agricultural jobs in 2016 (*Figure 4*). There were no agricultural businesses whose main income came from growing food crops under cover prior to 2014.

Figure 12. Average annual wages in the agricultural sector and top agricultural industries, adjusted to 2016 prices[1]
Washington state and Columbia Basin Area 4, South Eastern Area 5 and Eastern Area 6, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Industry by area	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Columbia Basin Area 4										
Total	**$24,820**	**$25,619**	**$24,000**	**$23,969**	**$25,393**	**$25,888**	**$25,694**	**$26,814**	**$27,152**	**$27,689**
Apple orchards	$20,774	$21,167	$18,302	$17,842	$20,607	$21,291	$22,356	$23,612	$24,149	$24,641
Postharvest crop activities (except cotton ginning)	$24,356	$25,942	$24,782	$24,993	$24,275	$26,854	$24,973	$26,566	$27,185	$28,449
Other noncitrus fruit farming	$19,115	$19,916	$19,054	$18,483	$20,314	$21,839	$20,548	$21,591	$21,705	$24,741
South Eastern Area 5										
Total	**$24,373**	**$24,789**	**$24,030**	**$23,876**	**$25,053**	**$25,297**	**$25,635**	**$26,984**	**$27,435**	**$27,946**
Apple orchards	$22,041	$21,965	$21,316	$21,370	$21,703	$23,953	$22,841	$25,197	$26,510	$26,692
Grape vineyards	$22,109	$23,284	$21,663	$21,804	$22,525	$23,475	$22,314	$24,413	$24,310	$25,082
Farm labor contractors and crew leaders	$23,264	$22,912	$14,173	$17,300	$17,619	$19,677	$20,638	$22,309	$20,133	$20,243
Eastern Area 6										
Total	**$23,608**	**$23,212**	**$23,721**	**$24,489**	**$25,269**	**$25,516**	**$26,293**	**$25,752**	**$24,196**	**$24,713**
Other food crops grown under cover[2]	NA	NA	NA	NA	NA	NA	NA	$31,776	$22,015	$22,240
Wheat farming	$25,191	$24,496	$25,512	$26,357	$27,743	$27,930	$28,773	$28,105	$26,964	$28,620
Floriculture production	$22,014	$22,667	$23,219	$23,991	$25,198	$24,640	$24,474	$24,508	$22,997	$23,004

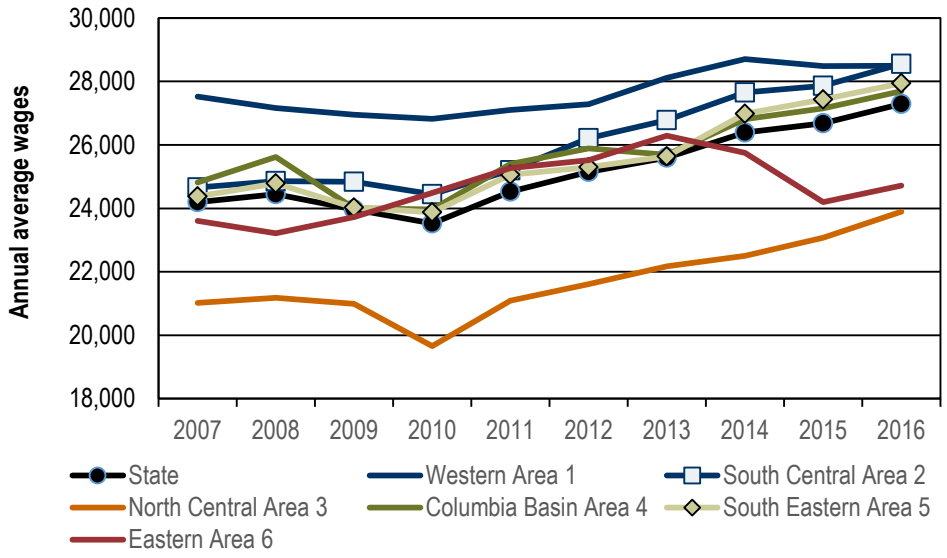
[1] Wages were adjusted to current prices in 2016 using the ECI price index for construction, extraction, farming, fishing, and forestry developed and used by BLS for wage adjustments.

[2] Neither employment nor wages were reported from 2007 through 2013 in this industry in this agricultural reporting area.

New businesses classified in the industry of other food crops grown under cover started operations in 2014 in Eastern Area 6.

Figure 13 shows that although average wages in Eastern Area 6 dropped significantly from 2013 through 2015, its average annual wages did not affect the average annual wages of the state. This is because agricultural employment in Eastern Area 6 is significantly smaller than agricultural employment in the state. For example, in 2015 agricultural covered employment in the state was 94,993 compared to 2,065 agricultural jobs in Eastern Area 6 (*Figure 4*).

Figure 13. Average annual wages in agriculture, adjusted to 2016 prices
Washington state and agricultural reporting areas, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW



Wages in Washington state agriculture experienced a steady increase from 2010, after the economic crisis that started in 2007.

Hourly average and median wage by industry

Hourly average and median wages for total agriculture and the 10 main agricultural industries in Washington state for 2016 are presented in *Figure 14*.[5] Average hourly wages were calculated by dividing total wages by total hours for each industry. Median hourly wages represent the hourly wages for the median worker in the wage distribution. Since this type of median wages can be biased if there are significant variances in hours among individual workers, we also calculated median wages weighted by numbers of hours ("weighted median").

[5] QCEW allows for calculating quarterly and average annual wages by industries and counties, or any aggregation of the counties (such as agricultural reporting area). However, because they do not have individual records for workers and hours worked, hourly wages or median wages cannot be calculated based on QCEW. Instead, we use the UI Wage File, which has information on where workers are located when the physical address reported by employers is the same as the location where the workers work. However, we have found that this is not always the case and we decided for this report calculate only hourly average and median wages at the state level to reduce bias.

In 2016, the average hourly wage in Washington state in agriculture was $15.29. For the 10 main agricultural industries, three industries had higher hourly wages than the state average. These three industries are other vegetable and melon farming, other food crops grown under cover and nursery and tree production. Unweighted and weighted median hourly wages for the state as a whole were $12.72 and $13.15, respectively. Other noncitrus fruit farming industry had the highest unweighted median hourly wages and other food crops grown under cover had the highest weighted median hourly wages. For all of the industries presented in *Figure 14*, median hourly wages are below average hourly wages. This implies that the majority of jobs, or more than 50 percent, pay less than the average hourly wage. In other words, the distribution of hourly wages is likely skewed toward higher wages.

Figure 14. Average and median hourly wages in the agricultural sector and for the main agricultural industries
Washington state, 2016
Source: Employment Security Department/WITS, UI Wage File

Industry	Hourly wages		
	Average	Median	Weighted median
Apple orchards	$14.52	$13.18	$13.06
Other noncitrus fruit farming	$15.08	$14.00	$13.32
Postharvest crop activities (except cotton ginning)	$15.11	$11.95	$12.75
All other miscellaneous crop farming	$15.20	$12.41	$12.84
Farm labor contractors and crew leaders	$13.78	$11.54	$12.20
Other food crops grown under cover	$16.22	$12.43	$13.83
Berry (except strawberry) farming	$14.53	$11.49	$12.68
Other vegetable and melon farming	$16.47	$12.00	$13.10
Grape vineyards	$14.07	$12.15	$12.64
Nursery and tree production	$15.84	$11.31	$12.52
Total	**$15.29**	**$12.72**	**$13.15**

Across the agricultural sector, median hourly wages were below average hourly wages.

Employment dynamics in agriculture

Jobs in the agricultural sector pay lower average wages than jobs in all other economic sectors except for jobs in the accommodation and food services sector.[6] Thus, agricultural workers have incentives to transfer, whenever possible, to jobs that offer higher wages, including to other jobs within the agricultural sector. In this section we explore two issues regarding employment dynamics in agriculture: 1) immigration trends and employment, and 2) movement of workers between agriculture and other sectors.

Immigration trends and analysis of labor supply shortage

Using surveys, many researchers have measured labor supply, labor supply components of migration and immigration and labor shortages in agriculture. For example, studies have found that the number of migrant workers coming to the U.S. has decreased in recent years, reducing agricultural labor supply. From 2007 to 2016, the estimated unauthorized immigrant population in the U.S. decreased 7.4 percent from 12.2 million to 11.3 million.[7] Another study estimated a decrease of 38 percent from 2007 to 2010 in the number of international migrants working in agriculture.[8]

Survey results of another study claim that this decrease of migrant and immigrant workers has contributed to labor shortages in Washington state. The results showed that 58 percent of responding farms in Washington were affected by labor shortages in 2016.[9] The decrease of migrant and immigrant workers has been credited to various factors, including higher rates of economic growth and more sluggish population growth in Latin America as well as tighter border enforcement in the U.S.[10]

A few researchers have taken a non-survey approach to identify and quantify labor shortages in agriculture. Some researchers found preliminary evidence of labor shortages in agricultural activities at the national level from 2010 to 2011.[11] They used simultaneous occurrence of rising wages (40 percent or more) and falling employment (50 percent or less) as a

[6] Washington state covered employment (QCEW): 2016 annual averages, revised, and 2015 annual averages, revised.

https://esdorchardstorage.blob.core.windows.net/esdwa/Default/ESDWAGOV/labor-market-info/Libraries/Industry-reports/QCEW/qcew-annual-averages-2016-revised.xlsx

https://esdorchardstorage.blob.core.windows.net/esdwa/Default/ESDWAGOV/labor-market-info/Libraries/Industry-reports/QCEW/qcew-annual-averages-2015-revised.xls

[7] Pew Research Center 2017. 5 Facts about illegal immigration in the U.S. http://www.pewresearch.org/fact-tank/2017/04/27/5-facts-about-illegal-immigration-in-the-u-s/

[8] Taylor, J. E., C. Diane, and A. Yunez-Naude. 2012. "The End of Farm Labor Abundance" Applied Economic Perspectives and Policy 34(4): 587-598.

[9] Clark, M. 2017. "Washington state's agricultural labor shortage." Washington Policy Center. www.washingtonpolicy.org/publications/detail/washington-states-agricultural-labor-shortage.

[10] Brady, M. P., R. K. Gallardo, S. Badruddozza, and X. Jiang. 2016. "Regional Equilibrium Wage Rate for Hired Farm Workers in the Tree Fruit Industry" Western Economics Forum, 15(1): 20-31.

Taylor, J. E., C. Diane, and A. Yunez-Naude. 2012. "The End of Farm Labor Abundance" Applied Economic Perspectives and Policy 34(4): 587-598.

[11] Hertz, T., and S. Zahniser. 2013. "Is There A Farm Labor Shortage?" American Journal of Agricultural Economics 95 (2): 476-481.

signal for labor shortages.[12] Shortages were found both in support activities such as soil preparation and planting, and in the production of various fruits and vegetables. In their study, evidence for labor shortage was concentrated in California and Michigan. The researchers did not find labor shortage in any county in Washington state from 2010 to 2011.

In this report we update the above results by applying the same method to 2015 and 2016 data for Washington state.

Our analysis indicates that at the state level, no agricultural industry showed evidence of labor shortage. *Figure 15* presents three industries that are closest to their criteria. These industries had a wage growth rate of more than 3 percent and an employment decrease of at least 5 percent from 2015 to 2016. Though one industry, crop harvesting, primarily by machine, shows a substantial drop in employment by percentage, it also has a limited employment base. Overall, using pre-established methods and definitions,[13] state-level data provide insufficient evidence of labor shortage.

Figure 15. Agricultural industries with rising wages and falling employment
Washington state, 2015 and 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Industry	Employment			Wages		
	2015	2016	Change	2015	2016	Change
Wheat farming	1,417	1,281	-9.5%	$26,451	$27,741	4.9%
Corn farming	124	108	-13.2%	$24,612	$26,916	9.4%
Crop harvesting, primarily by machine	148	89	-39.7%	$24,230	$26,782	10.5%

Agricultural industries do not show statewide labor shortages using the criteria of simultaneous rising wages and falling employment.

Because state-level data may mask local labor shortages, we conducted the same analysis using county-level data. However, we failed to find any agricultural industry that met the rising wage and falling employment criteria even at the county level. *Figure 16* shows 11 county industry combinations that merit describing. Since no industry at the county level met the criteria, we selected combinations with a gap greater than 25 percentage points between rising wages and falling employment to present in *Figure 16*. County industries that show a two-digit level of change in percentage in both employment and wages were Adams – apple orchards, Benton – all other miscellaneous crop farming, Franklin – potato farming, King – floriculture production, Klickitat – other vegetable and melon farming, Snohomish – other vegetable and melon farming and Yakima – wheat farming. In Benton, the farm labor contractors and crew leaders industry experienced a significant drop in employment (69.1 percent) but only a moderate increase in wages (9 percent).

[12] The requirement of less than a 50 percent decrease in employment is to exclude industries with a major change in the occupational composition of employment such as closure of a large establishment.

[13] Hertz, T., and S. Zahniser. 2013. "Is There A Farm Labor Shortage?" American Journal of Agricultural Economics 95 (2): 476-481.

Figure 16. Agricultural industries by county with rising wages and falling employment
Washington state, 2015 and 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

County	Industry	Employment			Wages		
		2015	2016	Change	2015	2016	Change
Adams	Apple orchards	324	239	-26.3%	$20,221	$27,738	37.2%
Benton	All other miscellaneous crop farming	208	158	-24.0%	$36,669	$40,558	10.6%
	Farm labor contractors and crew leaders	307	95	-69.1%	$12,312	$13,421	9.0%
Franklin	Apple orchards	1,454	1,093	-24.8%	$24,224	$25,200	4.0%
	Potato farming	421	367	-12.8%	$38,474	$43,287	12.5%
King	Floriculture production	100	84	-16.1%	$23,497	$30,216	28.6%
Klickitat	Apple orchards	63	51	-18.3%	$26,794	$28,626	6.8%
	Other vegetable and melon farming	302	270	-10.7%	$28,433	$33,838	19.0%
Snohomish	Other vegetable and melon farming	173	136	-21.6%	$14,597	$16,746	14.7%
Yakima	Nursery and tree production	354	235	-33.6%	$26,195	$28,592	9.2%
	Wheat farming	77	63	-18.2%	$13,185	$16,642	26.2%

Agricultural industries do not show labor shortages even at the county level.

We conclude this section by pointing out an important caveat in understanding the results. Though simple and straightforward, the used criteria are subject to further verification as their applicability relies entirely on changes of wages and employment ignoring other important factors such as economic rates of foreign countries whose workers are part of the agricultural labor supply. These rates influence the decision of workers to stay and work in their country or work in the U.S. See *Appendix 3* for more details.

Despite its limitations, the applied criteria was our first attempt at using administrative data to estimate labor shortages to either complement or substitute survey-based analyses. We believe this new approach overcomes some of the disadvantages in survey-based analyses such as low response rates or attempting to estimate small populations. As labor shortage continues to concern Washington growers, the demand for new and improved scientific methods will increase. We will continue pursuing ways to improve the measurement of labor shortages. Improved methods will yield more informative conclusions.

Job changes of workers within the agricultural sector and between agriculture and other sectors

Workers in the agricultural sector are likely to change jobs from one period to the next. We refer to these job changes as employment transfers.[14] The transfers include both workers changing jobs between sectors (two-digit NAICS), for example from agriculture (11 NAICS sector)[15] to accommodation and food services (72 NAICS sector), and workers changing jobs within the agricultural sector, for example from apple orchards (111331 NAICS industry) to potato farming (111211 NAICS industry). In this section, we summarize employment transfers between agricultural and nonfarm sectors at the two-digit NAICS level (sector level) and employment transfers within the agricultural sector. A brief description of the analysis can be found in *Appendix 4*.

Figure 17 shows employment, wages and employment transfers associated with agriculture and other sectors during 2016. We analyzed job changes based on quarterly UI wage files. Thus, *Figure 17* shows aggregated job changes in 2016 including changes between first and second quarter, second and third quarter, and third and fourth quarter. For the agricultural sector, average annual employment in 2016 was 101,054 with an average hourly wage of $15.11. For all the other nonfarm sectors, average annual employment in 2016 was slightly more than 3 million with an average hourly wage of $33.91.

In 2016, about 20 percent of the workforce in agriculture experienced job changes from nonfarm sectors to agricultural sectors. Agricultural employers hired 20,244 workers, who had worked in nonfarm sectors in a particular quarter, in the following quarter. Also, 21,969 workers who worked in an agricultural sector in a quarter exited the sector and were hired by employers in nonfarm sectors in the following quarter.

Many workers who changed jobs also experienced wage changes. Changing to an agricultural job was associated with a loss of average hourly wages of $1.75. Workers who changed from a nonfarm job to an agricultural job earned average hourly wages of $15.30 in their nonfarm jobs, compared to their average hourly agricultural wages of $13.55. We observed the opposite on workers who transferred out of an agricultural job to a nonfarm job. Changing to a nonfarm job was associated with an average gain of $1.45 per hour. Workers earned average hourly agricultural wages of $13.53 before they exited the sector, while they earned average hourly wage of $14.98 in their nonfarm jobs.

[14] Employment transfer is defined as workers who worked in an industry in an initial period, but then work in a different industry in the following period. For more details, see *Appendix 4*.

[15] For the purpose of this report, we exclude subsectors Forestry and Logging (113 NAICS) and Fishing, Hunting and Trapping (114 NAICS) and the industry group Support Activities for Forestry (1153 NAICS).

The last column of *Figure 17* presents the number of job changes within a sector. During 2016, 40,987 agricultural employees worked in a quarter in an agricultural industry different from the agricultural industry in which they had worked in the previous quarter.[16] This accounts for more than 40 percent, which is a considerably greater percentage than the 21.7 percent of job changes in all other sectors.

Job changes between and within sectors show that employment is more dynamic in agriculture compared to nonfarm sectors. Overall, taking into account the 20 percent of employment transfers into agriculture and the 40.6 percent of employment transfers within the agricultural sector, 60.6 percent of the agricultural workforce experienced job changes during 2016. This dynamic may be partly attributed to seasonality of employment in agriculture.

Figure 17. Employment transfers between and within agricultural and other sectors
Washington state, 2016
Source: Employment Security Department/WITS, UI Wage File

Sector	Annual employment	Average hourly wages	Employment transfers[1]	Hourly wages before move	Hourly wages after move	Employment transfer within a sector[2]
Agriculture	101,054	$15.11	21,969 21.7%	$13.53	$14.98	40,987 40.6%
Other sectors	3,008,633	$33.91	20,244 20.0%	$15.30	$13.55	654,172 21.7%

[1] The first row denotes the number of "move-out" from agriculture to other sectors and the second row denotes the number of "move-out" from the other sectors to agriculture. Agricultural employment is used as a base for percentage calculations for both rows.

[2] For other sectors, the number of moves within a sector is the total number of movements that occurred within each of the nonfarm sectors. The percentage is calculated by dividing the sum of the number of movements of all of the nonfarm sectors by the total employment in other sectors, i.e., 3,008,633.

Agriculture shows more dynamic employment (more between- and within-sector movement) than nonfarm sectors.

[16] See *Appendix 4* for a brief discussion of the challenges we experience in tracking workers' employment movements.

Prevailing wages and employment practices in Washington

In this section, we provide an overview of federal regulations that require ESD to conduct prevailing wages, and prevailing and normal or common practices surveys for seasonal agricultural workers. We then explain the guidelines used to determine prevailing wages and prevailing and normal or common practices for commodity activities included in the surveys. We also present data on the use of the H-2A program in Washington. Finally, we present the results of the 2016 Agricultural Peak Employment Wage and Practice Employer Survey.

An overview of the federal agricultural recruitment system

When agricultural employers are unable to attract enough local workers to perform seasonal jobs, they may seek additional domestic or foreign workers through the federal Agricultural Recruitment System (ARS) or the H-2A program. The ARS enables employers to file job orders for domestic workers at their local WorkSource office. WorkSource then recruits and refers workers from other regions in the state, or workers from other states, upon request.[17]

The H-2A program allows employers to hire foreign workers on a temporary basis to perform agricultural work when there are not enough U.S. workers available at the time employers need them. In order to use the H-2A program, employers must first demonstrate they were unable to recruit enough U.S. workers by filing a job order through the ARS.[18]

Employers who file job orders through the ARS must describe anticipated job duties and the conditions of employment. The language in agricultural job orders must also contain assurances that workers who live outside the area of intended employment will receive similar wages, similar benefits, and be subject to similar employment standards as are local workers. The intent of these assurances is to prevent the use of foreign or out-of-state U.S. workers from lowering wages and employment standards for local U.S. workers.

Federal regulations at 20 CFR 653.501 require that wages offered to workers hired through the ARS must not be less than the "prevailing wages" in the area of intended employment or the applicable federal or state minimum wage, whichever is higher.

According to the federal regulations at 20 CFR 655.122, the average hourly wages paid to workers hired through the H-2A program must be the highest of the Adverse Effect Wage Rate (AEWR),[19] the prevailing hourly

[17] For more information, see U.S. Department of Labor, Employment and Training Administration. "Agricultural Recruitment System (ARS)." www.doleta.gov/programs/ars.cfm (accessed November 8, 2017).

[18] For more information, see U.S. Department of Labor, Employment and Training Administration. "H-2A Temporary Agricultural Program." www.foreignlaborcert.doleta.gov/h-2a.cfm (accessed November 8, 2017).

[19] The AEWR is equal to the annual weighted average hourly wage rate for all non-supervisory field and livestock workers in a given region.

wage or piece rate, the agreed-upon collective bargaining wage, or the federal or state minimum wage, except where a special procedure is approved for an occupation or specific class of agricultural employment regardless of whether an employer pays a piece rate or an hourly rate for a given commodity activity. The U.S. Office of Foreign Labor Certification (OFLC) annually publishes the AEWR in a Federal Register notice, at which time it becomes effective for all workers hired through the ARS or the H-2A program. The AEWR in Washington was $12.69 per hour in 2016 and $13.38 per hour in 2017.[20]

Regulations contained at 20 CFR Part 655, subpart B, and 20 CFR Part 653, subpart F, define the "prevailing" and "normal or common" practices for seasonal U.S. agricultural workers that DOL may allow in job orders filed through the ARS. To establish allowable wages and practices, ESD reports on what employers offer or use for the week of the most recent growing season where they have the most workers (the peak week of employment).

Establishing prevailing wages

DOL provides funding to each State Employment Security Agency (SESA) to conduct surveys that help its regional offices establish the wages and practices that are allowable in job orders filed through the ARS or for the H-2A program. The guidelines to conduct these surveys are contained in the Employment Training Administration's (ETA) Handbooks 385 and 398.

Federal guidelines encourage SESAs to conduct prevailing wages and employment practices surveys for any commodity activity to which one or more of the following conditions apply:

1. One hundred or more workers were employed in the previous season, or are expected to be employed in the current season;
2. Foreign workers were employed in the previous season, or employers have requested or may be expected to request foreign workers in the current season, regardless of the number of workers involved;
3. The crop activity has an unusually complex wage structure, or there are other factors affecting the prevailing wage which can best be determined by a wage survey; or
4. The crop or crop activity has been designated by the national office as a major crop or crop activity either because of the importance of the production of this crop to the national economy or because large numbers of workers are employed in the crop activity in a number of different areas in the country.[21]

[20] For more information, see U.S. Department of Labor, Employment and Training Administration. "Adverse Effect Wage Rates — Year 2017." www.foreignlaborcert.doleta.gov/adverse.cfm (accessed November 8, 2017.

[21] U.S. Department of Labor, Employment and Training Administration. Handbook No. 385. Washington, D.C.: GPO, 1981: p. I-115.

ESD does not have administrative data on the number of workers employed nor comprehensive data on wage structures at the commodity activity level. Consequently, we use job descriptions contained in H-2A job orders to determine which commodity activities to analyze from the prevailing wages and employment practices surveys.

SESAs calculate the prevailing wage according to one of two rules. The first is the 40 percent rule, which states that if 40 percent or more of the seasonal U.S. workers surveyed for a given activity receive the same pay rate, then it becomes the prevailing wage. If two separate wage rates apply to 40 percent of U.S. seasonal workers surveyed for an activity, then both are prevailing wage rates.

The second rule is the 51 percent rule, which applies when no single wage rate covers 40 percent of the workers in the survey sample. This rule requires arraying arranging wage rates from highest to lowest and counting the number of workers who receive each wage rate.

Then, SESAs calculate the cumulative number of workers in the sample until 51 percent of all workers are covered. The wage rate that includes the worker in the 51st percentile of the wage distribution becomes the prevailing wage.

If there is not a single unit of payment for workers who perform a given activity (e.g., some workers are paid by the pound and some are paid by the hour), SESAs determine which pay unit applies to the largest number of workers. SESAs then determine the prevailing wage according to either the 40 percent or the 51 percent rule from among workers who receive the most common pay unit.[22]

Establishing prevailing and normal or common practices

A practice is prevailing if at least 50 percent of all employers who also hire at least 50 percent of all U.S. seasonal workers use the practice for a given commodity activity. The following practices are subject to the prevailing threshold: the provision of family housing to non-working family members, transportation and subsistence costs, and frequency of payment.

There is no specific quantitative threshold for normal or common practices. Instead, normal or common means, "situations which may be less than prevailing, but which clearly are not unusual or rare. The degree to which a practice is engaged in (or a benefit is provided) should be determined to be close to what is viewed (and measured) as 'prevailing,' but the degree by which the practice or benefit is measured and degree of proof needed to establish its acceptability for H-2A purposes is not as formal or stringent as 'prevailing' calls for."[23]

[22] U.S. Department of Labor, Employment and Training Administration. Handbook No. 385. Washington, D.C.: GPO, 1981: pp. I-116 — I-117.

[23] U.S. Department of Labor, Employment and Training Administration. Handbook No. 398. Washington, D.C.: GPO, 1988: p. II-7.

The following practices are subject to the normal or common threshold: minimum productivity standards, provision of tools and equipment, employee qualifications (e.g., experience) and the positive recruitment of U.S. nationals. Note also that minimum productivity standards only apply to activities for which the prevailing wage is a piece rate.[24]

Because H-2A regulations already establish requirements for other employment practices in agricultural job orders, ESD only surveys employers regarding the provision of family housing, minimum productivity standards and experience requirements. SESAs must survey both H-2A and non-H-2A employers concerning the provision of family housing and minimum productivity standards, but only non-H-2A employers concerning experience requirements.

Note that ESD only reports the number and percentage of employers and workers who offer or receive a benefit, or who are subject to an employment practice. Ultimately, DOL's Regional Administrators (RA) use their discretion when making normal or common practice determinations.

Submitted H-2A applications in Washington

From 2000 through 2013, ESD focused its prevailing wages and employment practices surveys on activities associated with growing apples, cherries and pears. This focus was largely due to the small number of commodity activities for which ESD received H-2A applications.

In 2015, ESD increased the number of commodities covered in the wage and practice survey to better align with submitted job orders and include the following: apricots; beans (fresh and dry); bees; beets; blackberries; blueberries; cabbage; carrots; collard greens; corn; goats; grapes; grass crops; green onions; herbs; kale; leeks; lettuce; mustard greens; nectarines; nursery crops (e.g., flowers, shrubs, transplants and trees); peaches; plums; pluots; radishes; raspberries; sheep; spinach; strawberries and zucchini. In 2016, ESD structured the wages and practices surveys to be non-proscriptive, allowing employers to report for any commodity.

The increase in H-2A applications over the last several years is the main reason ESD broadened its survey. *Figure 18* presents the number of applications submitted in Washington state and the number of applications certified nationwide.[25] It shows that there were only 26 applications submitted in Washington in 2007. By 2016, the number of applications submitted reached 146. The number of applications in Washington increased by more than 400 percent from 2007 to 2016.

There was variation in the number of H-2A applications submitted from year to year in Washington. Applications rose from 26 in 2007 to 34 in 2008 and then dropped to 18 in 2011. From 2012 to 2016, applications rose to 146. The average number of H-2A workers requested per

[24] U.S. Department of Labor, Employment and Training Administration. Handbook No. 398. Washington, D.C.: GPO, 1988: p. II-10.

[25] For more information about the national data, see U.S. Department of Labor, Employment and Training Administration. "OFLC Performance Data" www.foreignlaborcert.doleta.gov/performancedata.cfm (accessed December 14, 2017).

submitted application in Washington also varied from year to year. There was an average of 65 workers per application in 2007, rising up to an average of 177 workers per application in 2011. The average dropped to 93 workers per application in 2016. The total number of requested H-2A workers increased by more than 600 percent in Washington state, going from 1,688 in 2007 to 13,148 in 2016.

Figure 18. H-2A applications submitted*
U.S. and Washington state, 2007 through 2016
Sources: Employment Security Department, Employment Connections Division - Foreign Labor Certification Program; U.S. Department of Labor, Office of Foreign Labor Certification, Fiscal Year Performance Summaries

Year	Washington				United States			
	Employer applications submitted	Percent change	Workers requested	Percent change	Employer applications Submitted	Percent change	Workers requested	Percent change
2007	26	N/A	1,688	N/A	7,740	N/A	80,413	N/A
2008	34	30.8%	2,513	49.9%	8,096	4.6%	86,134	7.1%
2009	30	-11.8%	1,882	-25.1%	7,857	-3.0%	91,739	6.5%
2010	25	-16.7%	2,981	58.4%	7,378	-6.1%	89,177	-2.8%
2011	18	28.0%	3,182	6.7%	7,361	-0.2%	83,844	-6.0%
2012	33	83.3%	3,953	24.2%	8,047	9.3%	90,362	7.8%
2013	55	66.7%	6,194	56.7%	8,388	4.2%	105,735	17.0%
2014	82	49.1%	9,047	46.1%	9,405	12.1%	123,528	16.8%
2015	114	39.0%	12,081	33.5%	10,339	9.9%	145,874	18.1%
2016	146	28.1%	13,641	12.9%	8,684	-16.0%	172,654	18.4%

* N/A means not applicable, as 2007 is the base year for comparison. U.S. DOL reports national data according to the federal fiscal year. Washington state data do not include applications submitted for sheepherder, goat herder and beekeeper jobs.

The number of H-2A applications submitted in Washington during 2016 was more than five times greater than during 2007. The number of requested H-2A workers was more than eight times greater in 2016 than in 2007.

Prevailing wages in Washington

In this section, we present the wage results from the 2016 Agricultural Peak Employment Wage and Practice Employer Survey. Note that we only report commodity activities for which we obtained a sufficient sample of workers according to ETA guidelines.

The number of workers in a sample that are required to make a prevailing wage determination depends on the estimated population size for a given commodity activity. When the estimated population of workers for a commodity activity is greater than or equal to 100 and less than or equal to 2,999, the survey sample must include between 100 and 600 workers in order to publish a prevailing wage. When the estimated

population of workers for a commodity activity is greater than or equal to 3,000, the sample must include at least 15 percent of the estimated population in order to publish a prevailing wage.[26]

Figure 19 shows the results of the 2016 Agricultural Peak Employment Wage and Practice Employer Survey for commodity activities for which ESD was able to make a prevailing wage determination.

The prevailing wage was $12.69 per hour for apple farm laborer and apple pruning. Since the prevailing wage for each of these activities was an hourly rate that is lower than the AEWR for each activity, employers who hire workers through the ARS or the H-2A program must pay those workers the AEWR, which was $13.38 per hour in 2017.

For apple harvest, prevailing piece rates ranged from $20 per bin for Red Delicious to $26 per bin for Golden. The only hourly rate for apple harvest was associated with Honeycrisp at $15 per hour. The most commonly reported dimension per apple bin is 47" x 47" x 24.5".

For apple tree thinning, prevailing wages ranged from $12.69 per hour for Gala, Honeycrisp and Red Delicious to $12.75 per hour for Fuji.

The prevailing wage for apricot harvest was $12 per hour, and for hop harvest $14 per hour. Asparagus and blueberry harvest prevailing wages were both by the pound, with asparagus harvest at $0.27 per pound and blueberry harvest at $0.50 per pound.

ESD determined that the prevailing wage rates for cherry pruning and thinning were $10 per hour and $12.69 per hour, respectively. For red cherry harvest, the prevailing wage was $3 per 15-pound bucket; for Sweetheart, the prevailing wage was $5.50 per 30-pound lug. The prevailing wage for yellow cherries was $6 per 20-pound lug. The difference in lug size and prevailing wages is because yellow cherries are more sensitive to bruising. Consequently, yellow cherry harvesters must take greater care to avoid overloading their lugs.

For pear harvest, the prevailing wage was $22 for Bartlett and $26.50 for D'Anjou per 47"x47"x24.5" bin. Pear tree pruning was $10 per hour and thinning $12.69 per hour.

In addition to a prevailing wage, for piece rates, ESD surveyed for hourly earnings guarantees associated with each commodity activity. The hourly earnings guarantee is the minimum an employer must pay to a worker, regardless of how much a worker harvests. Hourly earnings guarantees ranged from $9.47 per hour to $12.75 per hour.

According to federal guidelines, employers who hire workers through the ARS or the H-2A program can pay the AEWR or the prevailing piece rate to workers engaged in commodity activities for which the prevailing wage is a piece rate. Regardless of which pay rate they use, employers who use the ARS or H-2A program to hire workers must ensure their average hourly wage rate in a given week is equal to or greater than the AEWR.

[26] U.S. Department of Labor, Employment and Training Administration. Handbook No. 385. Washington, D.C.: GPO, 1981: pp. I-114.

Figure 19. Prevailing wages by commodity activity*
Washington state, 2016
Source: Employment Security Department/WITS, 2016 Agricultural Peak Employment Wage and Practice Employer Survey

Crop	Activity	Prevailing wage rate	Pay unit	Hourly earnings guarantee	Dimension
Apples (all)	Farm laborer	$12.69	Hourly	N/A	N/A
Apples (all)	Tree pruning	$12.69	Hourly	N/A	N/A
Apples/Braeburn	Harvesting	$22.00	Bin	$12.69	47”x47”x24.5”
Apples/Fuji	Tree thinning	$12.75	Hourly	N/A	N/A
Apples/Gala	Harvesting	$23.00	Bin	$12.69	47”x47”x24.5”
Apples/Gala	Tree thinning	$12.69	Hourly	N/A	N/A
Apples/Golden	Harvesting	$26.00	Bin	$12.75	46”x43”x25.5”
Apples/Honeycrisp	Harvesting	$15.00	Hourly	N/A	N/A
Apples/Honeycrisp	Tree thinning	$12.69	Hourly	N/A	N/A
Apples/Red Delicious	Harvesting	$20.00	Bin	$12.69	N/A
Apples/Red Delicious	Tree thinning	$12.69	Hourly	N/A	N/A
Apricots (all)	Harvesting	$12.00	Hourly	N/A	N/A
Asparagus (all)	Harvesting	$0.27	Pound	$12.00	N/A
Blueberries (non-organic)	Harvesting	$0.50	Pound	$9.47	N/A
Cherries (all)	Tree pruning	$10.00	Hourly	N/A	N/A
Cherries (all)	Tree thinning	$12.69	Hourly	N/A	N/A
Cherries/Red	Harvesting	$3.00	Bucket	$12.69	15 pounds
Cherries/Sweetheart	Harvesting	$5.50	Lug	$12.69	30 pounds
Cherries/Yellow	Harvesting	$6.00	Lug	$9.47	20 pounds
Hops (non-organic)	Harvesting	$14.00	Hourly	N/A	N/A
Pears (all)	Tree pruning	$10.00	Hourly	N/A	N/A
Pears (all)	Tree thinning	$12.69	Hourly	N/A	N/A
Pears/Bartlett	Harvesting	$22.00	Bin	$12.69	47”x47”x24.5”
Pears/D’Anjou	Harvesting	$26.50	Bin	$12.69	47”x47”x24.5”

*Results include only commodity activities for which ESD received a sufficient sample size according to federal guidelines.

Seven prevailing wage rates were the 2016 AEWR of $12.69.

Prevailing and normal or common practices in Washington

Recall that a practice or benefit must apply to half of all employers who also hire half of all employees in our sample in order to be prevailing. The only practice included in the 2016 survey that is subject to the prevailing threshold is the provision of housing to non-working family members and whether that housing is free. ESD analyzed the provision of family housing by crop, variety and activity. For those crop-variety-activity combinations which had a sufficient sample size, ESD found no variation in the provision of family housing, as the majority of employers answered "no." This is similar to what was found for the 2015 analysis. It follows that the provision of free family housing is also not a prevailing practice.

There is no quantitative threshold for normal or common practices specified in ETA Handbook 398. As a result, ESD followed advice from DOL's Chicago National Processing Center (CNPC) when reporting minimum productivity and experience standards. According to CNPC, at least 33 percent of employers in a sample must report having any standard or practice before said practice is allowable as "normal or common."

In response to this advice, ESD chose first to determine whether 33 percent or more of the employers in our sample have any minimum productivity or experience standard. We then report the most common, quantifiable standard (e.g., harvesting a certain number of apple bins per day) reported by employers in our sample. In 2016, we did not have any occurrences by commodity activity where minimum productivity standards were normal and common. However, in 2015 ESD found minimum productivity standards for the following commodity varieties: Red Delicious apple harvesting, all other varieties apple harvesting, red and yellow cherry harvesting, blueberry harvesting and pear harvesting.

Experience requirements are also subject to the normal and common determination. ESD's analysis looked at experience requirements for non-H-2A employers by crop, variety and activity. In 2016, we found that there was no variation in experience requirements as the majority of employers included in the analysis indicated "no" or skipped the question. In contrast, for 2015, ESD did find experience for the following: apple and cherry harvesting, apple, cherry and pear pruning and apple thinning.

We attribute the lack of findings in prevailing and normal or common practices to either more employers who skipped the question or an increase of employers responding that they did not use that employment practice. Although the number of employers who responded to the surveys increased by 103 from 2,224 in 2015 to 2,327 in 2016, many more employers in 2016 either responded no or skipped practice questions.

Appendices

Appendix 1. Data characteristics and preparation

Quarterly Census of Employment and Wages (QCEW) data were aggregated by industry (six-digit NAICS) and by county. Employment numbers for multiple establishments were distributed between counties without duplications.

Quarterly wage data represent individual records for workers covered under the unemployment insurance system. These records include employer ID, hours worked and total wages paid. An employee can have multiple records, reflecting different employers in the same quarter. Matching wage records with employer directories allows us to identify industries in which employment takes place. We cleaned wage files by deleting all inactive records, all records with incorrect social security numbers and records with wrong wages or hours. We calculated quarterly hourly wages by dividing total wages by the number of hours worked. Records with hourly wages greater than $1,000 and less than $4 were deleted. Only records with total hours worked per quarter of more than 8 hours and not more than 2,880 hours were kept. For each quarterly file, for each individual, only one record with the largest number of hours worked was kept. We interpreted single remaining records as the primary jobs for each respective quarter.

Regional data on GDP and personal income comes from the U.S. Bureau of Economic Analysis (BEA). (For more details, see **www.bea.gov**.) BEA data for farm employment are different from QCEW and UI. BEA farm employment data contain farm output characteristics and they are estimates of the number of employees, rather than jobs as in QCEW and UI.

To adjust wages to current 2016 dollars, we used the Employment Cost Indexes (ECI) for construction, extraction, farming, fishing and forestry (see **www.bls.gov/web/eci/echistrynaics.txt**). These indices, developed by BLS, are used for inflation-adjusting wages in the Occupational Employment Statistic (OES) program.

Appendix 2. Decomposition of seasonal and non-seasonal employment

We define non-seasonal employment as stable employment and seasonal employment as variable employment. We estimate stable and variable employment at different geographical and industry levels. Geographically, we estimate at the state level and at the level of agricultural reporting areas as defined in *Appendix 6*.

Following the 2012 North America Industry Classification System (NAICS), we estimate at the economic sector level (two-digit NAICS) for Agriculture (11 NAICS) and at the industry level (six-digit NAICS) within this sector. However, for the purpose of this report, we exclude all the industries within the economic subsectors (three-digit NAICS) of forestry and logging (113 NAICS) and fishing, hunting and trapping (114 NACIS), and exclude industries within the industry group (four-digit NAICS) of support activities for forestry (1153 NACIS).

The level of aggregation determines stable and variable employment shares (fraction of employment). Generally, the shares of variable employment are lower for employment time series with less classification detail (e.g., two-digit NAICS) than series with greater classification detail (e.g., six-digit NAICS). The main reason for this is that all employment movements between series with greater classification detail are variable employment (e.g., employment movements between 111331 and 111339 industries) but become stable employment if they are within the same aggregated series (e.g., 1113 industry group). However, some exceptions can be attributed to model performance and to the limited coverage of detailed series.

Stable and variable employment estimates result from the disaggregation of covered employment using the following methods. Using standard statistical tools for time series decomposition, we can split employment time series into four basic components:

1. Seasonal: regular and predictable employment changes that recur each calendar year, caused by seasonal factors, which can include natural factors (changes in weather, regular variations in crop activities, etc.), administrative measures (starting and ending of the school year) and social, cultural or religious traditions (fixed holidays such as New Year's Day).

2. Cyclical: employment changes attributed to the business cycle in general or specific events.

3. Trend: shifts in long-term employment growth driven by fundamental structural changes and productivity trends in industries, rather than the cyclical fluctuations in employment.

4. Irregular: random employment changes not picked up by regular seasonal and cyclical components (e.g., non-regular seasonality, weather variation and labor strikes).

For this report, we used R's advanced decomposition models for time series. R is an open source language and environment for statistical computing and graphics.[27]

Decomposition of employment for each point in time (months, in our case) is:

Employment = combined trend + seasonal + irregular

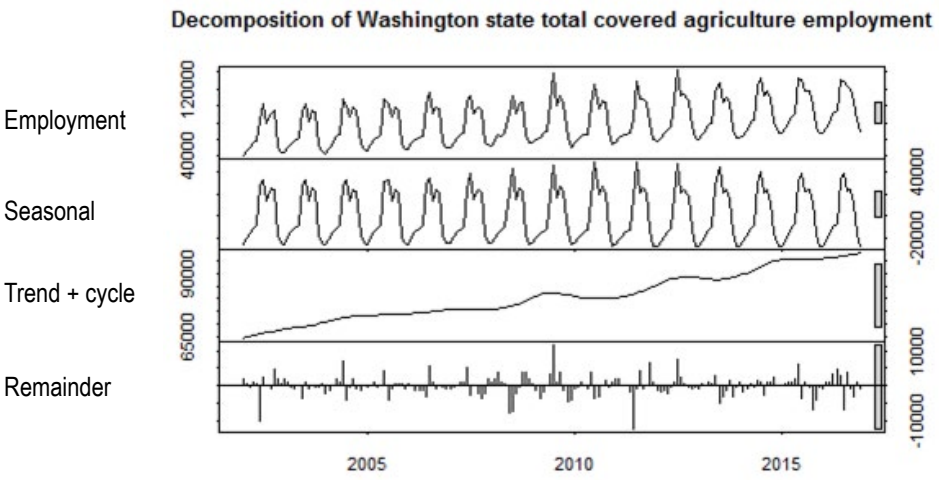
where combined trend refers to trend + cycle.

There are two steps in the process of time series decomposition:

1. Splitting of series between combined trend, seasonal and irregular components.
2. Splitting of the combined trend into trend and cyclical components.

The results of the decomposition of total agriculture employment are presented in *Appendix figure A2-1.*

Appendix figure A2-1. Total covered agricultural employment and its main components
Washington state, 2002 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW



The typical result of decomposition of time series into four components, using appropriate models, has the following characteristics. Trend expresses the movement of the mean. The three other components are variances around the mean. The totals of the seasonal components are close to zero in each year. The totals of cyclical components are eventually equal to zero for the entire period, but not for each year. The totals of irregular components are close to zero for the entire period. The differences between zero and totals, for the entire period for seasonal and irregular components, for the most part, cancel each other out. As a result, totals of variances around the mean for the entire period are close to zero.

[27] www.r-project.org/about.html.

We define stable and variable employment as follows. For each of the three variable components, seasonal, cycle and irregular, we calculate minimum values for each year.

Next, we renormalize each of the three variable components by subtracting minimums for each year from actual values. Next, we summarize all three renormalized variable components, from the decomposition, into one variable employment. Stable employment is defined by subtracting variable employment from the original covered employment. Only series where stable employment is positive for all month are deemed "non-failed" and are then considered for inclusion.

In short, we simply renormalize our three variables from being variances around means (positive and negative) to being positive differences from minimums, defined for each year.

Thus, instead of decomposing initial employment into four components (positive trend and mixed seasonal, cyclical and irregular), we decompose to just two components of stable employment (based on annual minimums) and variable employment (positive variances from minimums). These two components can be reasonably interpreted as non-seasonal employment (stable) and generalized seasonal employment. Seasonality in this case combines regular seasonal variations with the irregular component (related irregular and cyclical components).

Appendix 3. Application and limitations of Hertz and Zahniser's (2013) criteria that defines labor shortage

In this section, we briefly describe how we applied Hertz and Zahniser's criteria to identify labor shortages in Washington state and discuss a caveat to Hertz and Zahniser's approach to emphasize that our results should be understood with caution.

Hertz and Zahniser's criteria to identify labor shortages consists in identifying simultaneously in a geographic area an increase in wages (40 percent or more) and a decrease in employment (50 percent or less).

Like Hertz and Zahniser, we used QCEW data. However, we used employer records and quarterly wages instead of aggregated suppressed data and weekly wages. We aggregated quarterly data for 2015 and 2016 to create average annual employment and average annual wages (totals of quarterly wages divided by average annual employment). To make wages comparable from 2015 to 2016, we used the BLS ECI of 1.022. For this analysis, we only used industries with a minimum employment of 20.

Hertz and Zahniser's (2013) criteria hinge crucially on the classical assumption of unidirectional movement of labor supply and wage, i.e., labor supply increases (decreases) when wages increase (decrease); they regard a significant decrease in employment in response to a wage increase as a sign of labor shortage. Even if this theoretical assumption is valid in principle, it is often challenging to find empirical evidence that supports the theoretical relationship for the following conceptual and practical reasons.

First, even when the theory is valid, the relationship may only hold in the long run. In other words, there must exist a certain time lag between a shock and an adjustment to the shock. For instance, when there is a wage rise in agriculture, it takes time for workers to respond to the change in the labor market, as the response requires a series of steps such as recognition of the change, acquisition of new skill sets, application submission and job interview and so on. Thus, a contemporaneous comparison between wage and labor supply may not reveal the relationship that is expected in principle.

The second reason is more practical. Data available to researchers are the end result of past and immediate changes in wages, employers' production costs, workers' skills, job opportunities, preferences and other factors that affect the supply and demand of labor. In other words, what researchers observe in the available data may not be the result of an immediate change in one factor but of past or immediate changes of several other factors. For example, when the AEWR increases the number of workers in cherry orchards does not necessarily increase if a late frost reduces the production of cherries in a region. Thus, it is the researchers' challenge to isolate the effect of wage changes on employment from the effect of the other factors, which is lacking in Hertz and Zahniser's approach. In fact, our correlation analysis reveals a negative relationship between wages and employment, which appears to contradict the

main premise of Hertz and Zahniser's approach: if wages increase then employment increases. Our correlation analysis may suggest that the number of workers demanded by agricultural employers has more influence in the agricultural labor market than the number of agricultural workers working or willing to work in agriculture.

Appendix 4. Analysis of employment transfer

To analyze transfers of agricultural employment we used the Unemployment Insurance Wage File from fourth quarter 2015 through fourth quarter 2016. These data were processed as described in the Data Sources section of this report. Analysis was conducted for all pairs of consecutive quarters (e.g., fourth quarter 2015 to first quarter 2016, first quarter 2016 to second quarter 2016, etc.). For each pair of quarterly wage files, we calculated the following:

a. Number of workers, wages, hours and hourly wages for the base quarter. Hourly wages are calculated by dividing cell wages by cell hours.

b. Number of workers that had existed in the base quarter, but disappeared in the next quarter. For these workers, we also calculated wages, hours and hourly wages.

c. Number of workers that had not existed in the base quarter, but appeared in the next one. For these workers, we also calculated wages, hours and hourly wages.

d. Matrices of workers that showed movement from one industry to another. For each industry pair, we calculated numbers of workers, wages and hourly wages before and after the movement.

e. Numbers of workers, which moved from one employer to another within an industry (i.e., movement within an industry). For each industry, we also calculated wages, hours and hourly wages before and after the movement.

We annualize our data in the following manner. For wages and hours, we made totals for all quarters for each category. For counts of jobs, we calculated annual averages for 2016. Hourly wages were calculated by dividing wage totals for each year by hour totals. As a result of our processes, for each six-digit NAICS industry we have the following quarterly and annual indicators for hourly wages and employment that serve as the basis of employment movement analysis:

- moved out of industry and wage file (lost);
- moved in industry and wage file (new);
- moved from an industry to other industries (inter-industry transfer out);
- moved from other industries to an industry (inter-industry transfer in);
- moved inside industry from one employer to another (in-industry transfer);

Despite our endeavor to keep track of workers' movement as accurately as possible, there were two challenges stemming from the nature of the data.

We used NAICS codes associated with each employer to identify workers' movements between sectors and industries. It is not unusual that one employer has multiple business activities where each of the activities can correspond to different NAICS codes. However, the UI Wage File allows

only one NAICS code for each employer ID. Therefore, in our analysis, a worker can be identified as experiencing industry transfer without job change due to NAICS code changes associated with his/her employer.

The other challenge comes from the employees' side. Likewise, an individual worker often works for multiple employers. In such cases, for each worker we defined a job with the longest working hour in a given quarter as the "primary job" for the individual for that quarter. We then defined that a worker has experienced an employment transfer when the worker's primary job is not the same in two consecutive periods. Consequently, an employment transfer can occur even in the case that the new primary job is not a new job for a given worker, which can lead to an overestimation of employment dynamics.

Appendix 5. Reporting area data tables

Appendix figure A5-1. Total covered agricultural employment in agricultural reporting areas
Washington state, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Area	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Western Area 1	10,995	11,205	10,966	11,014	11,118	11,255	10,931	11,190	12,244	13,756
South Central Area 2	23,102	24,677	25,808	25,008	26,330	28,326	28,359	30,712	31,691	32,714
North Central Area 3	17,302	16,859	18,950	18,209	18,595	18,904	18,611	20,116	20,086	19,763
Columbia Basin Area 4	9,741	9,822	10,399	10,188	10,535	11,874	11,915	12,743	12,690	12,308
South Eastern Area 5	13,238	13,407	14,495	14,301	13,962	15,791	15,607	15,778	16,216	16,042
Eastern Area 6	1,383	1,428	1,470	1,477	1,515	1,599	1,621	1,669	2,065	2,480

Appendix figure A5-2. Monthly seasonal, non-seasonal and total employment in agriculture
Washington state, 2014 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Employment	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total 2014	**62,407**	**64,381**	**71,667**	**80,853**	**83,278**	**123,487**	**133,821**	**111,643**	**118,252**	**107,922**	**81,309**	**67,480**
Seasonal 2014	3,817	5,535	12,564	21,492	23,658	63,609	73,686	51,252	57,608	47,029	20,169	6,098
Non-seasonal 2014	58,590	58,846	59,103	59,361	59,620	59,878	60,135	60,391	60,644	60,893	61,140	61,382
Total 2015	**68,105**	**72,714**	**79,231**	**86,472**	**90,443**	**132,725**	**130,288**	**118,207**	**118,166**	**99,900**	**75,699**	**67,971**
Seasonal 2015	9,388	13,764	20,052	27,070	30,821	72,888	70,240	57,951	57,706	39,240	14,840	6,916
Non-seasonal 2015	58,717	58,950	59,179	59,402	59,622	59,837	60,048	60,256	60,460	60,660	60,859	61,055
Total 2016	**67,278**	**73,798**	**79,561**	**90,069**	**94,723**	**131,474**	**128,158**	**122,706**	**119,684**	**105,059**	**82,606**	**69,704**
Seasonal 2016	5,928	12,256	17,828	28,146	32,611	69,174	65,671	60,031	56,822	42,010	19,371	6,282
Non-seasonal 2016	61,350	61,542	61,733	61,923	62,112	62,300	62,487	62,675	62,862	63,049	63,235	63,422

Appendix figure A5-3. Average covered seasonal employment in agriculture*
Washington state, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Area	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
State	**28,907**	**33,897**	**32,062**	**31,291**	**40,012**	**29,698**	**32,214**	**32,210**	**35,073**	**34,677**
Western Area 1	3,446	3,355	2,875	2,852	3,707	2,937	2,849	3,066	3,157	2,957
South Central Area 2	9,082	10,525	9,881	10,257	13,266	9,916	10,734	11,389	12,851	12,082
North Central Area 3	8,153	11,056	9,043	8,887	11,116	7,781	8,218	8,559	9,347	10,805
Columbia Basin Area 4	4,237	4,500	4,778	4,715	5,253	4,562	4,699	4,947	5,038	5,430
South Eastern Area 5	6,800	7,641	6,840	6,308	7,890	5,973	7,278	6,147	6,576	6,318
Eastern Area 6	326	340	351	371	409	373	405	450	533	470

*The summation of seasonal agricultural employment across the agricultural reporting areas does not add up to state total employment. This is because seasonal adjustments are based on statistical models that depend on levels of aggregation.

Appendix figure A5-4. Percentage of covered seasonal employment in agriculture
Washington state, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Area	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Western Area 1	31.3%	29.9%	26.2%	25.9%	33.3%	26.1%	26.1%	27.4%	25.8%	21.5%
South Central Area 2	39.3%	42.7%	38.3%	41.0%	50.4%	35.0%	37.9%	37.1%	40.5%	36.9%
North Central Area 3	47.1%	65.6%	47.7%	48.8%	59.8%	41.2%	44.2%	42.5%	46.5%	54.7%
Columbia Basin Area 4	43.5%	45.8%	45.9%	46.3%	49.9%	38.4%	39.4%	38.8%	39.7%	44.1%
South Eastern Area 5	51.4%	57.0%	47.2%	44.1%	56.5%	37.8%	46.6%	39.0%	40.6%	39.4%
Eastern Area 6	23.6%	23.8%	23.8%	25.1%	27.0%	23.3%	25.0%	27.0%	25.8%	19.0%

Appendix figure A5-5. Monthly covered seasonal agricultural employment by agricultural reporting area*
Washington state, January 2016 through December 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Western Area 1	**354**	**1,151**	**1,231**	**2,240**	**2,164**	**4,448**	**8,375**	**5,879**	**3,627**	**2,959**	**1,636**	**1,419**
South Central Area 2	2,551	4,700	6,887	10,062	11,587	22,417	19,688	21,339	22,334	16,105	5,532	1,783
North Central Area 3	4,109	5,154	6,228	8,698	8,906	20,736	20,526	16,376	16,105	11,406	7,313	4,103
Columbia Basin Area 4	**1,321**	**2,317**	**3,331**	**4,751**	**5,591**	**9,755**	**8,569**	**8,405**	**8,808**	**7,037**	**3,617**	**1,656**
South Eastern Area 5	885	2,209	3,301	5,433	7,448	14,842	11,126	10,349	8,535	7,166	4,049	474
Eastern Area 6	96	111	236	351	304	362	769	1,064	794	720	607	230

* The number of seasonal employment, measured at the state level is not the same as the summation of seasonal agricultural employment across agricultural reporting areas. This is because statistical estimation for seasonality depends on levels of aggregation.

Appendix figure A5-6. Monthly covered seasonal employment by select agricultural industries
Washington state and agricultural reporting areas*, January 2016 through December 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Area and industry	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
State - Apple orchards	3,534	4,862	6,108	10,531	11,648	19,334	19,437	21,899	22,041	18,469	9,747	2,557
State - Other noncitrus fruit farming	4,976	5,834	6,936	8,378	9,775	23,638	17,457	16,210	14,557	10,033	5,304	4,539
State - Other postharvest crop activities	2,419	2,227	2,292	2,002	1,627	9,148	7,541	4,345	5,023	5,617	3,151	3,028
South Central - Apple orchards	1,454	1,745	1,987	3,026	3,440	5,420	6,190	8,214	7,701	6,112	2,537	1,084
North Central - Apple orchards	1,571	2,196	2,631	4,566	4,330	7,852	7,911	7,784	8,135	6,894	3,851	1,308
Columbia Basin - Apple orchards	1,015	1,367	1,702	2,466	2,466	3,477	3,296	3,382	4,171	3,499	2,196	1,192
South Eastern - Apple orchards	1,014	1,076	1,305	1,999	2,941	4,090	3,536	3,979	3,434	3,421	2,643	494
Western - Nursery and tree production	71	157	286	374	388	303	246	203	145	161	410	477
Eastern - Wheat farming	30	39	52	70	77	98	303	506	308	143	109	101

*Western Area 1 and Eastern Area 6 are omitted due to their small amount of seasonal employment in these industries.

Appendix figure A5-7. Average annual wages in the agricultural sector (adjusted to 2016 prices)
Washington state and agricultural reporting areas, 2007 through 2016
Source: Employment Security Department/WITS; U.S. Bureau of Labor Statistics, QCEW

Area	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
State	**$24,196**	**$24,448**	**$23,965**	**$23,527**	**$24,527**	**$25,143**	**$25,601**	**$26,392**	**$26,685**	**$27,288**
Western Area 1	$27,524	$27,166	$26,950	$26,824	$27,103	$27,278	$28,116	$28,706	$28,489	$28,492
South Central Area 2	$24,652	$24,862	$24,834	$24,448	$25,193	$26,214	$26,778	$27,653	$27,867	$28,551
North Central Area 3	$21,021	$21,179	$20,993	$19,656	$21,089	$21,614	$22,172	$22,499	$23,076	$23,898
Columbia Basin Area 4	$24,820	$25,619	$24,000	$23,969	$25,393	$25,888	$25,694	$26,814	$27,152	$27,689
South Eastern Area 5	$24,373	$24,789	$24,030	$23,876	$25,053	$25,297	$25,635	$26,984	$27,435	$27,946
Eastern Area 6	$23,608	$23,212	$23,721	$24,489	$25,269	$25,516	$26,293	$25,752	$24,196	$24,713

Appendix 6. Agricultural reporting areas

Appendix figure A6-1. Agricultural reporting areas
Washington state, 2016
Source: Employment Security Department/WITS

Western Area 1
Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Skamania, Snohomish, Thurston, Wahkiakum and Whatcom

South Central Area 2
Klickitat and Yakima

North Central Area 3
Chelan, Douglas, Kittitas and Okanogan

Columbia Basin Area 4
Adams and Grant

South Eastern Area 5
Benton, Franklin and Walla Walla

Eastern Area 6
Asotin, Columbia, Ferry, Garfield, Lincoln, Pend Oreille, Spokane, Stevents and Whitman