Farmworkers at Risk

The Growing Dangers of Pesticides and Heat

www.ucsusa.org/resources/farmworkers-at-risk

Appendix 1 : Methodology
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Appendix I: Methodology

PESTICIDES

PESTICIDE USE AND APPLICATION RATES

We used state and county-level data from the Pesticide National Synthesis Project of the US Geological Survey (USGS) to identify heavily used pesticides and annual agricultural pesticide application rates in each of three select states (California, Florida, and Washington; see Table 1). Specifically, we identified the top 10 pesticides by weight for each state, using the "Epest-high" estimates (which extrapolate values for counties where survey data are not available) and aggregating the labor-intensive crop categories of "Vegetables and fruit" and "Orchards and grapes" (Baker and Stone 2015; Stone 2013).

We also estimated state-level pesticide application rate by dividing the total kilograms of all agricultural pesticides applied by the total acres of harvested crops in 2017 (from the 2017 Census of Agriculture; NASS 2019). Since agriculture is highly variable within states, we identified the top 10 crop-producing counties for a more detailed analysis. We retrieved the value of crop sales for each county from the 2017 Census of Agriculture (NASS 2019) and calculated the proportion of state crop sales for which each county was responsible.

To assess pesticide application rates across these agriculturally important counties, we repeated the procedure applied at the state level (above), dividing the total kilograms of pesticides applied in the top counties by the total acres of harvested crops in those counties. The USGS dataset that we relied on for estimates of pesticide use includes both direct and extrapolated estimates, and the reliability of the estimated quantities decreases with scale (Baker and Stone 2015; Stone 2013). So while this dataset is well suited for the state and multicounty analysis of rates and ranking that we performed, it would not be appropriate for county-by-county comparisons.

PESTICIDE HAZARDS

We compiled information on the hazards associated with the identified top pesticides using two sources. First, we consulted the Pesticide Action Network International List of Highly Hazardous Pesticides, maintained since 2009 (PANI 2019). This list includes compounds that are known to fit into one or more of the following four categories: (1) acutely toxic; (2) long-term health effects: carcinogenic, reproductive and developmental toxicants, endocrine disruptor; (3) environmental toxicity: bioaccumulative, persistent in water or soil, toxic to aquatic organisms, toxic to bees; and (4) listed as highly hazardous in international guidelines or conventions. We noted when pesticides were listed in Categories 1 and 2, as these are the most pertinent to farmworker health.

Some agricultural pesticides with severe risk for acute injury, such as sulfuric acid, do not appear on the list. Therefore, we also collated documents describing the toxicity category and safety warnings that the US Environmental Protection Agency (EPA) mandates appear on pesticide product labels. Because aggregated data on label warnings and requirements are not easily available (Shaw and Harned 2013), for each of the 18 identified pesticides, we used the EPA Pesticide Chemical Search to search for documents of pesticide registration decisions, which detail the required safety warnings for the compound. When we were unable to locate official EPA decisions that dealt unambiguously with a given pesticide, we searched broadly to locate product labels that contained the mandated safety warnings. Note that the source documents collated for this analysis each refer to a specific pesticide formulation. The EPA mandated safety warnings may vary for other formulations based on the same active ingredient.

PESTICIDE SOURCE DOCUMENTS

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HEAT INDEX

HEAT INDEX CALCULATIONS

We used daily maximum temperature and daily minimum relative humidity from downscaled climate model simulations from 1971 to 2000 to calculate the maximum heat index for each day in the warm season as in Dahl and colleagues (2019a). We then calculated the annual average number of days with a heat index above 80°F.

CAVEATS AND LIMITATIONS

This analysis is intended to provide insight into the nature of extreme heat across the contiguous United States, which is already dangerous and becoming worse as climate changes. When applying these results to any location or population, a number of limitations should be considered:

- The heat index is based on physiological assumptions to assess the impacts of hot and humid weather on humans. Variations in age, clothing thickness, health, height, physical activity, and weight are not accounted for in the heat index calculation (Steadman 1979). The index also does not include cloudiness, shade levels, wind speed, or any other factors, although those are known to affect heat-related impacts.

- The downscaling methodology used (Multivariate Adaptive Constructed Analogs) is intended to capture climate extremes. A different climate downscaling technique (e.g., Localized Constructed Analogs) could produce different results.
- The results we report are the average over the 30-year period between 1971 and 2000. Because substantial warming has occurred over this period, the number of extreme heat index days presented here is a conservative estimate of recent conditions only.
- We have not examined daily minimum heat index, which typically occurs at night and strongly influences incidences of both heat-related illness and heat-related death (Oleson et al. 2015; Basara et al. 2010; Karl and Knight 1997).
- We examine only the total of individual heat days, although the duration of a given heat event is an important factor in shaping an event's resulting health impacts (Guirguis et al. 2013; Anderson and Bell 2011; Meehl and Tebaldi 2004). This tends to make our characterization of the health impacts of these results conservative.
- We do not consider how acclimatization or adaptation to heat could reduce the consequences of heat impacts. Health impacts are affected by individual acclimatization (physiological adaptation, behavioral changes) and external adaptive measures, such as air-conditioning, which can help reduce exposure and vulnerability to heat and lower rates of heat-related illnesses and mortality (Vaidyanathan et al. 2019; USEIA 2018). There are, however, limits to the human ability to adapt to heat (Pal and Eltahir 2016).

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Technical Appendix II: Detailed Results

Table A1. Farmworkers, Agricultural Characteristics, Pesticides, and Extreme Heat

State (1-24)	Hired Farm Labor (1,000)	Cropland Harvested (1,000 acres)	Sales: All Crops (million $)	Sales: Fruits, Nuts, Vegetables (million $)	Pesticides Applied (1,000 kg)	Days with Heat Index >80°F	State (25-48)	Hired Farm Labor (1,000)	Cropland Harvested (1,000 acres)	Sales: All Crops (million $)	Sales: Fruits, Nuts, Vegetables (million $)	Pesticides Applied (1,000 kg)	Days with Heat Index >80°F
CA	378	7,858	33,354	27,876	63,457	110	**CO**	37	5,917	2,239	304	8,584	54
WA	229	4,472	6,983	4,710	34,022	23	**AR**	29	7,099	3,625	65	15,250	144
TX	144	17,595	6,894	566	26,440	165	**MS**	27	4,174	2,292	119	8,753	161
FL	96	2,093	5,705	2,583	24,544	194	**AL**	26	2,206	1,212	78	4,828	158
OR	86	2,965	3,283	1,151	7,421	43	**SD**	26	16,372	5,167	4	15,714	72
MI	77	7,215	4,644	976	8,299	32	**NJ**	25	412	985	364	397	82
IA	73	24,348	13,833	31	32,890	77	**AZ**	25	916	2,094	1,009	1,884	129
WI	72	9,235	4,067	720	10,007	48	**ND**	24	23,976	6,681	241	19,697	52
MN	71	20,054	10,192	409	20,125	45	**LA**	23	3,315	2,061	44	8,013	172
NC	67	4,407	3,735	663	12,741	130	**MT**	22	9,901	1,585	52	8,187	49
PA	61	3,932	2,781	359	3,870	56	**SC**	21	1,600	1,096	194	4,909	152
OH	59	10,191	5,426	193	11,512	78	**NM**	20	806	651	308	932	99
NY	56	3,581	2,108	778	3,674	40	**UT**	19	1,063	561	56	621	80
IL	56	22,701	13,844	143	33,593	96	**MD**	15	1,290	948	95	2,482	101
KY	53	5,474	2,541	42	6,399	113	**ME**	13	360	409	273	508	21
MO	50	13,486	5,476	94	17,767	110	**MA**	13	141	364	190	117	45
GA	49	3,629	3,272	988	16,637	165	**CT**	12	122	420	66	106	56
ID	46	4,576	3,211	1,172	19,669	35	**WY**	10	1,545	318	2	473	38
NE	45	19,460	9,311	97	26,425	85	**WV**	9	736	153	33	216	82
IN	44	12,346	7,121	152	15,680	85	**VT**	8	418	187	43	112	28
KS	43	21,837	6,460	27	29,685	114	**NV**	5	574	276	18	708	72
OK	42	7,813	1,517	68	5,871	137	**NH**	5	86	108	31	44	37
TN	40	4,566	2,182	112	7,280	129	**DE**	4	435	326	64	820	97
VA	40	2,613	1,361	188	3,206	106	**RI**	2	14	41	11	10	50

Note: States are ranked by the number of hired farm laborers, according to the 2017 Census of Agriculture. Total cropland harvested; total crop sales; and sales of fruits, nuts, and vegetables are also from the 2017 Census of Agriculture. Pesticide application rates represent total amounts applied for agriculture in 2016 (USGS 2018). Days between April and October with a heat index above 80°F are calculated from 1971 to 2000. See Technical Appendix I for detailed methods.
SOURCES: NASS 2019; USGS 2018.

Table A2. Farmworkers, Agricultural Characteristics, Pesticides, and Extreme Heat in Top 10 Counties in California, Florida, and Washington

State	Ag District	County	Harvested Acres (1,000)	Crop Sales (million $)	Crop Sales,% of State Total	Pesticides (kg 1,000)	Days with Heat Index >80°F
CA	San Joaquin Valley	Fresno	1,002	4,084	0.12	11,974	98
CA	Central Coast	Monterey	299	4,078	0.12	3,277	86
CA	San Joaquin Valley	Kern	747	3,436	0.10	8,856	130
CA	San Joaquin Valley	Tulare	600	2,223	0.07	4,066	81
CA	San Joaquin Valley	San Joaquin	483	1,627	0.05	4,116	133
CA	Southern California	Ventura	97	1,621	0.05	1,787	88
CA	Southern California	Santa Barbara	120	1,489	0.04	2,122	73
CA	San Joaquin Valley	Stanislaus	374	1,339	0.04	2,211	131
CA	San Joaquin Valley	Merced	497	1,290	0.04	3,532	138
CA	Southern California	Imperial	467	1,223	0.04	1,716	193
FL	Southern	Palm Beach	374	886	0.16	1,795	204
FL	Southern	Miami-Dade	50	828	0.15	636	207
FL	Central	Hillsborough	35	410	0.07	2,912	200
FL	Southern	Manatee	60	321	0.06	1,724	202
FL	Southern	Hendry	162	302	0.05	2,243	206
FL	Central	Polk	102	241	0.04	2,697	201
FL	Central	Orange	11	224	0.04	212	196
FL	Central	Lake	31	196	0.03	443	194
FL	Southern	Collier	40	184	0.03	859	208
FL	Central	Volusia	17	184	0.03	52	188
WA	East Central	Grant	569	1,480	0.23	9,434	67
WA	Central	Yakima	261	1,417	0.22	2,682	36
WA	Central	Benton	289	769	0.12	4,609	75
WA	East Central	Franklin	248	469	0.07	5,768	74
WA	Central	Okanogan	65	298	0.05	1,139	25
WA	East Central	Adams	364	260	0.04	4,723	66
WA	Southeast	Whitman	746	260	0.04	738	55
WA	Central	Chelan	24	256	0.04	874	18
WA	Western	Skagit	55	191	0.03	498	6
WA	East Central	Douglas	185	180	0.03	622	52

Note: States are ranked by the number of hired farm laborers, according to the 2017 Census of Agriculture. Total cropland harvested; total crop sales; and sales of fruits, nuts, and vegetables are also from the 2017 Census of Agriculture. Pesticide application rates represent total amounts applied for agriculture in 2016 (USGS 2018). Days between April and October with a heat index above 80°F are calculated from 1971 to 2000. See Technical Appendix I for detailed methods.
SOURCES: NASS 2019; USGS 2018

Table A3. Top Pesticides Applied to Fruit, Orchard Crops, Vegetables Threaten Farmworkers

	Pesticides Applied (1,000 kg)			Indicators of Pesticide Toxicity			
Pesticide	CA	FL	WA	Acute Toxicity	Long-Term Effects	Contact Danger	Toxicity Category
Sulfur	21,368	1,838	1,610			Yes	CAUTION
Dichloropropene	5,073	3,257	7,076		Yes	Yes	WARNING
Petroleum Oil	4,637	5,784	5,402		Yes	Yes	CAUTION
Metam Potassium	3,935	1,968	1,839		Yes	Yes	DANGER
Chloropicrin	3,626	2,111	196	Yes		Yes	DANGER
Glyphosate	2,997	1,211	364		Yes		CAUTION
Kaolin Clay	1,628	33	527				CAUTION
Metam	1,394	339	9,139		Yes	Yes	DANGER
Copper Hydroxide	1,150	629	47	Yes			WARNING
Petroleum Distillate	734	0	0		Yes	Yes	CAUTION
Calcium Polysulfide	719	0	721			Yes	DANGER
Mancozeb	625	246	245		Yes	Yes	CAUTION
Chlorothalonil	456	312	148	Yes	Yes	Yes	DANGER
Sulfuric Acid	0	0	2,176			Yes	DANGER
Allyl Isothiocyanate	0	689	0			Yes	DANGER

Note: This table includes the top 10 pesticides applied to fruit, orchard crops, and vegetables in three select states, as well as indicators of their toxicities. "Contact danger" indicates that Environmental Protection Agency (EPA) mandated safety warnings include a risk of injury or death through contact with the skin. EPA toxicity categories are associated with the following signal words: "danger," "warning, and "caution." See Technical Appendix I for more information.
SOURCES: PANI 2019; USGS 2018; see Pesticide Source Documents in Technical Appendix 1.