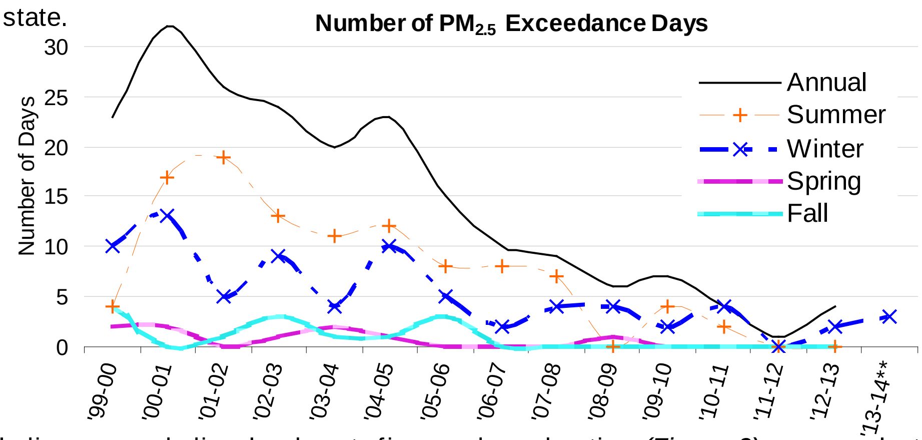
Seasonal Report

2013 Fine Particles

MARYLAND
Department of the Environment

OVERVIEW

Fine particle pollution (also called $PM_{2.5}$) is a concern throughout the year in Maryland. $PM_{2.5}$ is not dependent on sunlight and warmth like ozone, allowing it to impact Maryland's air quality any time of the year. Over the past decade, the number of days with high $PM_{2.5}$ concentrations has substantially decreased due to the adoption of clean air regulations *(Figure 1)*. When $PM_{2.5}$ monitoring began in 1999, $PM_{2.5}$ pollution was a significant health concern most often during the summer months, with a secondary peak in winter and only minor $PM_{2.5}$ pollution in the spring and fall. In recent years, however, health concerns were more frequent in winter as days with high $PM_{2.5}$ concentrations outnumber those in summer. Even though Maryland has seen decreased $PM_{2.5}$ pollution overall, wintertime $PM_{2.5}$ pollution continues to be a periodic problem for the state.



Because of the very small size of $PM_{2.5}$ pollution, it can penetrate deep into the lungs and is a breathing and heart health concern if airborne concentrations are too high. When $PM_{2.5}$ concentrations create health concerns for sensitive populations, the Air Quality Index (AQI) exceeds 100. The annual severity of $PM_{2.5}$ is measured by the number of days the daily 24-hour average concentration of $PM_{2.5}$ (midnight to midnight) exceeds the AQI value of 100 *(see bottom of page)* in a given year[1]. Currently no short-term (i.e. hourly) National Ambient Air Quality [Health] Standard (NAAQS) exists.

ORIGINS OF FINE PARTICLES

$PM_{2.5}$ can originate from many different sources including car and diesel exhaust, fires and combustion *(Figure 2)*, power plant emissions, and can even be created by reactions between these types of pollution, water vapor and sunlight. Weather plays a pivotal role determining the concentration of $PM_{2.5}$ in the air, both directly and indirectly. Abundant moisture in the air aids in the formation of $PM_{2.5}$. The warmer air of summer typically holds more moisture making it directly more supportive of $PM_{2.5}$. Indirectly, the electrical load on power plants is higher during summer heat, resulting in higher direct emissions of $PM_{2.5}$ and $PM_{2.5}$ precursor gasses on warm, muggy days. However, with clean air regulations imposed on power plants, Maryland's summer $PM_{2.5}$ exceedance days have been reduced by over 95% since 2002.

So why does $PM_{2.5}$ peak in both summer and winter? After all, winter often has very little moisture in the air due to the cold temperatures. Instead of moisture, cold winter weather causes air to be trapped very near the ground by something called an inversion *(Figure 3)*. The inversion plays a direct role in pollution concentration. It acts like a lid, trapping all the pollution produced between it and the ground. Without a way for pollution to disperse it accumulates, causing high $PM_{2.5}$ concentrations. Indirectly, the cold weather increases heating demand, causing the 33% of Maryland households using electrical heat[1] to increase energy generation at power plants. Though most power plant smoke-stacks are tall and rise above the inversion. However, nearly 1 out of every 5 homes in Maryland (18%) have wood burning capability[2]. While both power plants and wood burning may increase $PM_{2.5}$ pollution, the regional contribution from residential wood burning during the winter season is more significant to the $PM_{2.5}$ issue.

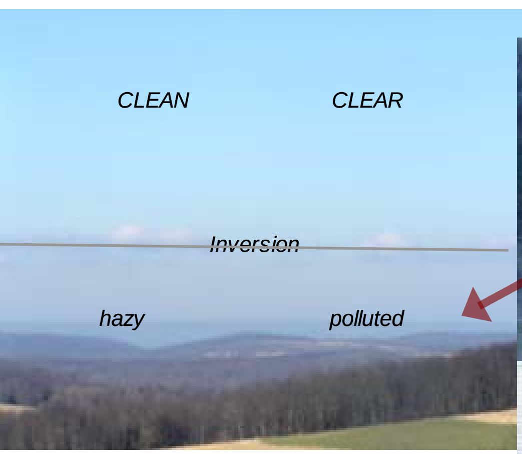


*Figure 1: (Top Right) Number of days where the AQI reached 100 or greater at any $PM_{2.5}$ monitor in Maryland annually and for each season, 1999-2013. Seasonal statistics for winter use the previous calendar year's November and December. For example the '11-12 winter uses November and December of 2011 and January and February of 2012. **The '13-14 column shows the number of days in November and December of 2013 only. Annual days with AQI >100 is January through December of a given year. Figure 2: (Middle) Chimney smoke is an example of $PM_{2.5}$ pollution. Figure 3: (Left) This image shows the inversion present near Frostburg, MD on December 3rd., 2013. The air below the inversion (as marked on image) is hazy and polluted because locally emitted pollution can not escape into the upper atmosphere. Conversely, the upper atmosphere is quite clear because little pollution has escaped from below the inversion, keeping $PM_{2.5}$ concentrations there low.*

2013 FINE PARTICLES AIR QUALITY

The 2013 calendar year experienced four days when the AQI was greater than 100 due to $PM_{2.5}$. All four days occurred during the winter *(Table 1, page 2)*. During the summer the $PM_{2.5}$ AQI never exceeded 100 due largely to continued success with clean air regulations and the mild summer weather and clean ocean air (See 2013 Ozone Report). What is striking about the poor $PM_{2.5}$ air quality in winter months of 2013 is that the majority of pollution was experienced in less populated and more remote areas of the state.

AQI 0-50 Good	51-100 Moderate	101-150 USG*	151-200 Unhealthy	201-300 Very Unhealthy	301-500 Hazardous

[1] Report based on the revised PM2.5 AQI implemented in 2013.
[2] Maryland Department of Natural Resources
*Unhealthy for Sensitive Groups

Picture Source: MDE; Minnesota PCA

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MDE

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FEATURED EPISODE: December 2-4, 2013

Western Maryland valleys and the I-95 corridor both experienced high $PM_{2.5}$ concentrations during the first few days in December, but the sources and mechanics of the pollution formation are unique. Western Maryland valleys act to trap pollution produced locally in the natural "bowl" shaped by the valley *(Figure 4)*. Cities such as Hagerstown that reside within these valleys are subject to the pollution that forms there. When an inversion is present, as was the case in early December, the atmosphere puts a cap on the "bowl" of the valley, trapping all locally produced pollution. In the case of western Maryland, much of this may be wood smoke from heat production. While there are fewer people in this region compared to the I-95 corridor, the unique geography traps locally produced pollution efficiently, compensating for the less densely populated area.

Maryland's $PM_{2.5}$ Season Exceedance Days

Date	# Exc Mon	Mon. Name	High Conc	AQI
29-Jan	1	Oldtown	38.5	108
2-Dec	1	Hagerstown	43.3	120
3-Dec	1	Hagerstown	45.7	126
4-Dec	2	Hagerstown	39.2	110

Table 1: The above table provides details of the days when $PM_{2.5}$ pollution reached an AQI of at least 100. The second column lists the number of monitors that reached at least 100 AQ. The other monitor to surpass 100 AQI on Dec. 4 was in Cecil County, MD. Column three lists the highest monitor on that day. Columns four and five list the concentration in µg/m³ and AQI, respectively.

A prolonged period of relatively light winds and warming temperatures led to dramatic increases in $PM_{2.5}$ pollution across the Mid-Atlantic region, with the highest concentrations in western Maryland valleys. Warming temperatures beginning December 1st resulted in $PM_{2.5}$ pollution increasing across nearly all of Maryland. Because warm air first arrives above the ground it traps pollutants by creating a temperature inversion. The $PM_{2.5}$ pollution was particularly bad in western Maryland mountain valleys because the mountains in these areas act like the sides of a bowl, helping to pool pollution. Without an inversion, winds will blow pollution away, but with an inversion (due to warming temperatures above the valley) the valley acts like a fireplace with the chimney clogged *(Figure 4)*.

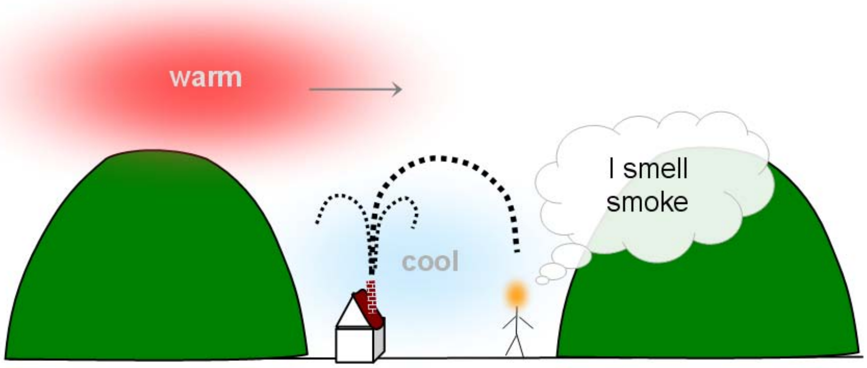

Figure 4: The typical environmental setup during periods with high particle pollution in western Maryland mountain valleys. Warm air rides over the top of the valleys, often along the top of the ridges of the mountains, while the bottom of the valley stays much cooler. This causes pollution to fall back towards the surface and remain trapped in the valley. In these situations, pollution from sources such as wood burning stoves remains within the valley and may often be smelled by local residents.

December 1st was a perfect example of warm air moving over the top of a cold Hagerstown valley. The maximum daily temperature at Hagerstown was 12 degrees Fahrenheit colder than at Baltimore-Washington International Airport (BWI) near Baltimore indicating cold air in Hagerstown valley was trapped beneath warm air moving in to the state *(Figure 5)*. On this same day, the $PM_{2.5}$ 24-hour average concentration peaked above 30µg/m³, almost a doubling of the previous day triggering several air quality alerts. Because air was trapped in the valley, local pollution sources such as wood burning units likely contributed to the elevated $PM_{2.5}$ concentrations during this period. Hagerstown valley warmed through the duration of the poor air quality event but remained under an inversion through December 4th. With warming air temperatures, heat generating units are often not run as hot and the amount of wood burned is reduced. However, such a situation may actually produce more $PM_{2.5}$ pollution. As wood fires cool and smolder the wood burns less efficiently. The cooler fire results in incomplete combustion of wood which produces excessive amounts of $PM_{2.5}$ pollution. Such a scenario could potentially account for the worsening conditions through December 3rd as the temperature warmed, but there is no conclusive evidence of this. A front passing through on December 5th cleaned the air and ended the poor air quality episode.

With western Maryland's abundant forests, burning wood is a practical and cheap means for heat. However, the impacts of wood smoke on air pollution can be significant. The public should be aware of the best burning practices, such as using Environmental Protection Agency (EPA) certified wood stoves to reduce wood smoke. More clean wood burning tips are available from the EPA.

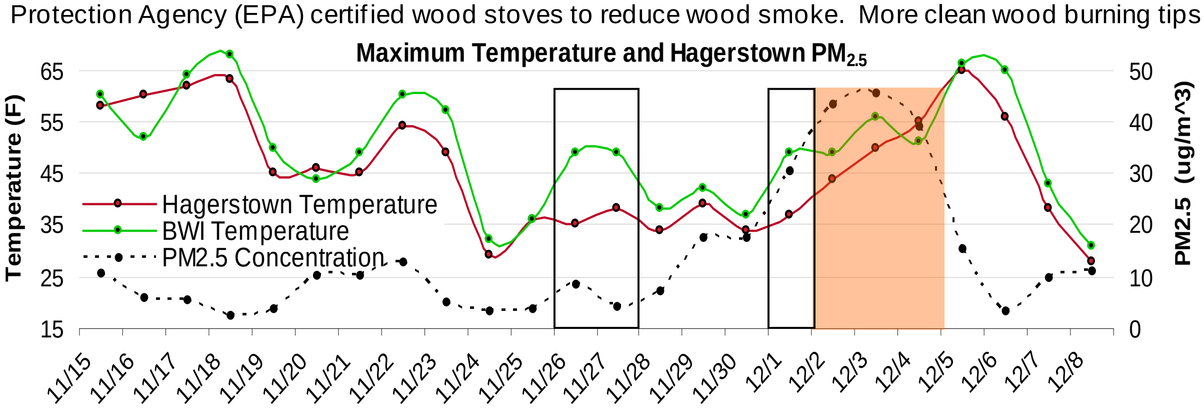

Figure 5: A graph of temperature at Hagerstown (red), BWI airport (green) and $PM_{2.5}$ concentration at Hagerstown (black). The orange box shows when the AQI was above 100 at Hagerstown. Hollow boxes show two periods where significant temperature differences exist between BWI and Hagerstown. Normally the temperature at these locations track well together, but when an inversion is present, as is true beginning on December 1st, BWI is often much warmer.

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