Clearing the Air

Palm Oil, Peat Destruction, and Air Pollution

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Executive Summary

When landscape fires in Southeast Asia burn out of control, hazardous air pollution—in the form of a debilitating haze—spreads across the region. This report discusses how deforestation, the draining of peatlands, and the frequent use of fire in unsustainable palm oil production are key contributors to the haze and its health impacts on millions of residents across this region.

The health-threatening haze results from landscape fires that release hundreds of chemicals and large quantities of particulate matter. Winds spread these pollutants across the region, pushing air quality levels to hazardous levels. During severe haze events, tourism plummets, and schools and businesses close. Exposed populations experience both short- and long-term health impacts that range from eye and skin irritation to serious respiratory and cardiovascular problems and even death. Each year, 110,000 deaths in Southeast Asia can be attributed to particulate matter exposure from these fires.

Cultivation of oil palm trees—the fruit of which is seen here being harvested in Sumatra, Indonesia—must be done responsibly, without deforestation, peatland destruction, or the use of fire, in order to reduce the occurrence of haze in Southeast Asia.

Union of Concerned Scientists

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Forest and peat fires in Indonesia, such as this one in Central Kalimantan, Indonesia, can easily become uncontrollable and spread dangerous smoke and haze across the region, significantly impacting human health.

Fire is often used to prepare land for agricultural production, and approximately 20 percent of the fires are known to be located on land designated for oil palm plantations (and the number is likely higher). In the coming years, Southeast Asia's serious problems with frequent, debilitating haze are likely to grow worse. Several current practices will combine with predicted future climatic conditions, most notably decreased rainfall, to make uncontrolled landscape fires more likely. Widespread deforestation leaves land more flammable than intact forests, and the draining of peatlands—normally wet and unburnable soils—leaves them susceptible to fires that can burn for months.

While bans on these practices do exist, the lack of enforcement ensures that fires remain widespread. To reduce the incidence of fire and consequent health effects for millions of people in local communities, these bans must be strictly enforced, particularly during very dry years. Governments should invest in monitoring technology to locate fire sources swiftly and accurately and take action against the responsible parties. Political will for action is beginning to be seen in the region through new laws, fines levied against companies committing illegal deforestation, and international agreements—a trend that must gain and maintain momentum.

A market must be created for palm oil produced without deforestation or drainage of peatlands. Investors must recognize the economic risks inherent in these unsustainable and damaging practices, and consumers should demand products made from palm oil produced sustainably and with a value on human health. Only a concerted international effort will effect a shift toward sustainable production practices and the air quality supportive of residents' health.

Introduction

Fire is commonly used in Southeast Asia to clear agricultural land and to eliminate debris for the establishment of oil palm plantations, pulp and paper plantations, and other crops. Every year, these fires blaze out of control during the dry season, and flames engulf plantations, forests, and, increasingly, huge swaths of drained peatlands. Smoke and haze blanket the region, sometimes for weeks at a time. Heavy haze has grounded aircraft, hindered tourism, and shut down schools and businesses. The air quality frequently reaches levels hazardous to human health. People exposed to the haze caused by these fires experience a host of health effects ranging

from relatively minor symptoms for a large majority of the affected population to much more serious impacts for a small minority (WHO 1999). The fires in Southeast Asia are responsible for 110,000 deaths each year (Johnston et. al 2012).

The fires and resulting haze are closely associated with the destruction of tropical forests and the draining of swampy, carbon-rich peatlands to make way for oil palm plantations (see the box). Palm oil is an important global commodity, used in products ranging from deodorants and toothpastes to cookies and chocolates. Palm oil has a growing market presence and constitutes more than 30 percent of vegetable oil produced worldwide, with around 85 percent originating in Indonesia and Malaysia. As market demand for palm oil rises, the land on which it is grown has expanded accordingly (Carlson et al. 2013). This land for plantations is increasingly coming from drained peatlands, a trend that is of particular concern because when dried peat is ignited by fire, it can smolder for months, contributing to haze (Carlson et al. 2013; Miettinen et al. 2012).

Because of changing climatic conditions, continued deforestation, and ongoing peatland drainage in Southeast Asia, areas with large tracts of land devoted to oil palm plantations are likely to be at increased risk of fire in the coming years. While haze events caused by landscape fires occurred as far back as the 1960s, their frequency has been increasing, and

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they are now an annual occurrence—of varying intensity—during the Southeast Asian dry season (Gaveau et al. 2014; Johnston et al. 2012; Varkkey 2011; Field et al. 2009; Ostermann and Brauer 2001). Continued deforestation and peatland drainage will likely mean even more landscape fires in the coming years, especially when combined with future shifts in climatic conditions that will make the dry season even drier (Li et al. 2007). The effects of deforestation and peatland drainage are already being seen; in June and July of 2013 the haze was particularly acute despite a fairly typical weather pattern, as seen in Figure 1 (Gaveau et al. 2014).

In 2014, new efforts by national governments and international agreements set the stage for progress in reducing haze pollution, highlighting an increased recognition of the

Linkages between Palm Oil Production and Southeast Asian Haze

Oil palm plantations contribute significantly to deforestation in Southeast Asia, together with logging and the production of other agricultural commodities. In Indonesia, for example, more than 3,800 square miles (10,000 square kilometers)—an area the twice the size of Delaware—were deforested for oil palm cultivation between 2000 and 2010 (Abood et al., 2014).

Every year, plantations, degraded forests, and drained peatlands burn. However, until recently it has been difficult to determine exactly what land is burning and for what purpose; hence, it has been difficult to assign responsibility for the fires and resulting haze. Identifying the particular agricultural use of land can be a laborious and time-intensive project, and it is not always possible to associate newly cleared land with the specific crop being grown. Moreover, oil palm plantations are not clearly identifiable in satellite images until several years after they are planted. Even now, because many companies do not publicly share the location of their plantations, and government records of land usage are often incomplete or inaccurate, it can be difficult to determine on whose land a fire is burning, and why.

Only recently have the technology and information been available to locate these fires, and these tools are necessary for the accurate assessment of responsibility. In early 2014, an analysis traced 11 percent of recent fires in Sumatra, Indonesia, to oil palm plantations (Sizer et al. 2014). During the haze episode in the summer of 2013, around 20 percent of fires were located on land designated for oil palm plantations (Boucher 2013; Sizer et al. 2013). This number likely underestimates the contribution of the palm oil industry because not all of the land planted with oil palm or cleared for these plantations is in a database that allows land to be traced to a specific crop. As monitoring technology improves and information sharing continues, researchers will have more tools at their disposal to better track the fires that are the source of haze and determine the land use involved.

dangers posed by the fires and their associated health impacts on the regional populations. Yet these are only the first steps needed to ensure the health and safety of millions of Southeast Asians. It is also crucial to address the practices that make the landscape more flammable. These nascent national and international efforts must be joined by the actions of other people and organizations on a global scale—consumers, manufacturers, traders, investors—to ensure that palm oil production practices that raze tropical forests, drain peatlands, and set fire to the land do not continue. Global action is needed to end this constellation of actions that lead directly to major haze events and damage the health of the people of Southeast Asia.

The Expanding Footprint of Palm Oil Production and its Health-Threatening Haze

Worldwide, oil palm is cultivated on more than 67,000 square miles of land (175,000 square kilometers)—an area larger than Washington state. This growing industry continues to expand globally, with operations in many tropical areas including Africa and Central and South America. However, more than 68% of the land area used to grow palm oil is found in Southeast Asia, specifically in Indonesia and Malaysia (FAO 2014).

In Indonesia, around 11 percent of deforestation that occurred between 2000 and 2010 was linked to oil palm cultivation (Abood et al., 2014). Much of this deforestation is concentrated in specific regions with correspondingly high percentages of deforestation attributable to oil palm plantations. For example, during that period, oil palm plantations were directly responsible for about 57 percent of the total deforestation in Kalimantan, Indonesia (on the island of Borneo) (Carlson et al. 2013).

Palm oil is a major contributor to the economies in these Southeast Asian nations and is therefore looked upon favorably by some governments. In Indonesia, the oil palm plantation sector is responsible for around 3 million jobs (BAPPENAS 2009). In Malaysia, the minister of land development for the state of Sarawak, on the island of Borneo, stated a goal to

FIGURE 1. Spread of Haze in South Asia on June 21, 2013

This map shows the extent of haze on June 21, 2013, with prevailing winds driving the haze east from Sumatra, Indonesia over Singapore and Peninsular Malaysia.

SOURCE: ADAPTED FROM ASEAN SPECIALIZED METEOROLOGICAL CENTRE.

double the size of oil palm plantations there by 2020. Oil palm plantations are a key strategy for economic development in rural areas (Mongabay 2010), and because of the short-term economic benefits of planting oil palm, some deforestation for oil palm cultivation is encouraged by governments. However, it is estimated that more than half (53 percent) of palm oil exports from Indonesia and one-quarter (24 percent) from Malaysia are linked to deforestation that is illegal (Lawson 2014). Because some deforestation is legal, the percentage of palm oil linked to both legal and illegal deforestation is therefore higher yet.

Strong incentives thus exist for the expansion of the palm oil industry in Southeast Asia. However, current industry practices of deforestation and peatland destruction bring far-reaching detrimental consequences, harming the environment and public health throughout the region.

USE OF FIRES FOR LAND PREPARATION

Fire is one of the primary methods employed to clear and maintain agricultural land, in part because it is inexpensive (Suyanto et al. 2004; Barber and Schweithelm 2000). To prepare land for agriculture using fire costs between 30 to 98 percent less than using mechanical techniques (Varkkey 2011; Suyanto et al. 2004). The use of fires to clear land is technically illegal in Indonesia, with bans enacted in 1984 and renewed in 1997. However, due to Indonesia's decentralized governance, this law often remains unenforced. In a district in West Kalimantan, Indonesia, the use of fire was so widespread between 1989 and 2008 that it was the primary reason for 93 percent of all deforestation (Carlson et al. 2012).

Even with bans on burning to clear land, the magnitude of landscape fires in Sumatra and Kalimantan—two prime oil palm–growing regions in Indonesia—has increased (Gaveau et al. 2014; Frankenberg et al. 2005). Much of this is due to land use change. As the amount of land controlled by agriculture has risen, so has the use of fire to clear land—in one study, fire was linked to more than half of all large-scale plantation development (Dennis et al. 2005; Frankenberg et al. 2005). Other influences on the rise in landscape fires are increased settlement, deforestation, and logging in the region, because secondary forests (those that have been affected by disturbances such as selective logging) are more susceptible to fire than intact forests (Frankenberg et al. 2005; Suyanto et al. 2004). Fire has reportedly also been used as a weapon in land disputes, with fires set on land without permission, and it has been used to increase soil fertility through the production of ash (Dennis et al. 2005; Frankenberg et al. 2005; Suyanto et al. 2004; Ketterings et al. 1999). Lastly, many companies, including those claiming zero-burning agricultural techniques, use fire to burn debris (Suyanto et al. 2004).

The clear short-term economic advantages of fire have led to its widespread, well-documented use for clearing and preparing agricultural land. Yet even fires that start small can easily rage out of control, spewing smoke and haze into the atmosphere and subjecting local populations to hazardous levels of air pollutants that harm their short- and long-term health.

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INCREASING INCIDENCE OF FIRES AND DESTRUCTION OF PEATLAND

As palm oil producers look for new land to cultivate in tropical regions, they increasingly turn to peatlands. In Kalimantan, Indonesia, for example, the percentage of land converted to oil palm plantations from peatlands increased more than five-fold from 1990 to 2010 (Carlson et al. 2013). In order to use peatlands for agricultural production, the forest and other vegetation must be removed and the swampy soils drained, which increases the cost of establishing plantations on peat soils (Carlson et al. 2013; Carlson et al. 2012). However even with these additional costs, palm oil production on peatlands is still profitable.

Producers cultivate peatlands despite the particular importance of protecting these lands from development. Tropical peat soils have high water tables that normally keep organic materials from fully decomposing, and as a result these soils sequester large amounts of carbon. Once drained, these previously waterlogged soils are highly flammable, and when ignited, they can smolder for months.

The drained peat is particularly flammable, not surprisingly, during the dry season. But despite this danger, fires are set near and in peatlands to burn off the vegetation in preparation for planting. Although the fires are intended to be controlled, they often escape. Moreover, they burn not only the surface vegetation but also roots, humus, woody

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Fires on peat can be very difficult to extinguish, burning slowly for months or even years due to the depth and organic density of peat soils.

fragments, and the peat soil itself. The surface fires can progress to deep fires that generally burn at a depth of 8 to 20 inches (20–50 centimeters) and can burn yet more deeply. Sub-surface peat fires can also travel horizontally, sometimes leaving the surface unburned. Once deep peat begins to burn, the fires become very difficult to extinguish. Even heavy rainfall may not extinguish the fires completely, and they can continue to smolder for months or even years (Usup et al. 2004).

Peat fires contribute significantly to the haze pollution in Indonesia and throughout the region. The haze event was particularly severe in 1997–1998, when haze spread from Indonesia and Malaysia to Singapore, Brunei, Thailand, and the Philippines. It lasted for weeks, closing schools and businesses and affecting the health of millions of residents. The severity of this episode was in large part due to fires on peat, which accounted for between 60 and 80 percent of the smoke and haze that enveloped the region (Varkkey 2011; BAPPENAS 1999). The single largest contributor was at the site of a failed government initiative, the "Mega Rice Project" in central Kalimantan, Indonesia, where approximately 3,800 square miles (10,000 square kilometers) had been prepared for agriculture and then abandoned, leaving the area—predominantly peatland—particularly susceptible to burning (Field et al. 2009).

The severity of this episode was in large part due to fires on peat, which accounted for between 60 and 80 percent of the smoke and haze that enveloped the region.

The large-scale development of oil palm plantations continues. For example, at the urging of local government, peatlands in Sarawak, Malaysia are now undergoing conversion. Thus, despite the enormous risks of the agricultural cultivation of peatlands, efforts by producers as well as governments to develop peatlands continue.

> ***Recent observations have shown that drought years are no longer a necessary precursor to major haze events resulting from the clearing of peatlands.***

IMPACT OF INCREASINGLY SEVERE DROUGHTS

The frequency and duration of fires is worsened by increasingly common drought conditions in Southeast Asia, due to climate change and other climatic phenomena. Fire and the resulting haze have become annual occurrences, with their effects especially severe in drought years (Field et al. 2009). Such droughts are brought on by climatic phenomena such as the El Niño Southern Oscillation (ENSO)—a naturally occurring event that happens when the equatorial Pacific Ocean warms and causes regionally decreased rainfall and a delay in the rainy season—and a positive Indian Ocean dipole—a similar phenomenon occurring in the equatorial Indian Ocean. These extra-dry conditions mean that the fires purposely set for agricultural clearing are more likely to burn out of control. In fact, records from 1960 to 2006 show that all major haze events occurred during low rainfall years caused by one or both of these climatic phenomena (Field et al. 2009).

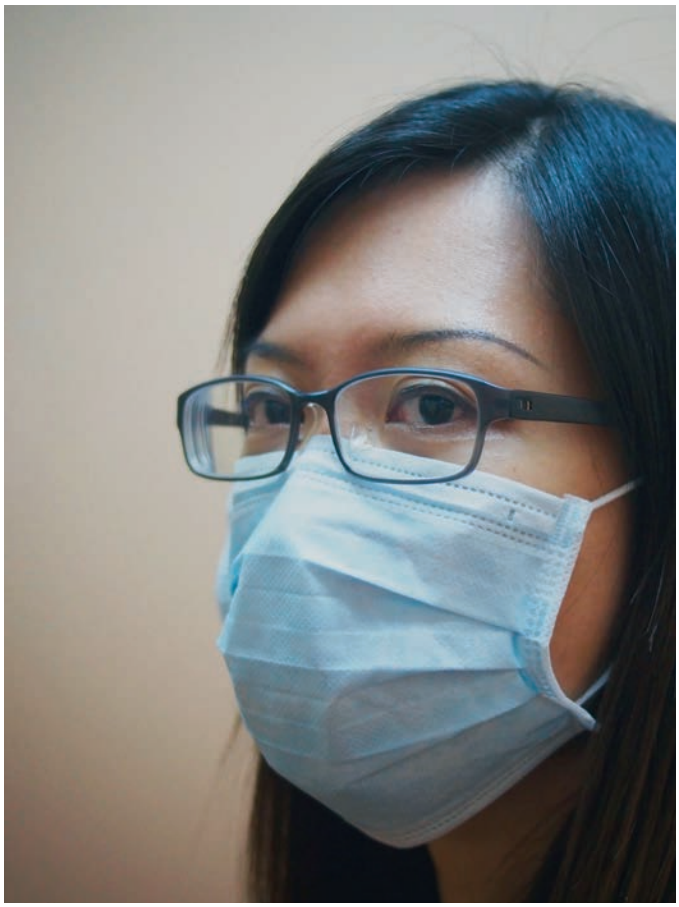
Haze during El Niño years is generally more pronounced. Particulate emissions from landscape fires in a very dry El Niño year may be 50 times higher than in years when Southeast Asia experiences above-average rainfall (Marlier et al. 2013). Compounding the problem of the increased number of fires, the lack of rainfall during El Niño years means that precipitation rarely clears the air of particulate matter (Marlier et al. 2013). The ENSO phenomenon in 1997–1998 was the strongest of such episodes on record since 1950, when measurements began. Strong ENSO conditions extended the dry season; fires began in June of 1997, and haze peaked in September and October. Fires burned across the region—concentrated on Sumatra and Kalimantan, Indonesia—and the haze spread to neighboring countries.

Climate change will also affect rainfall in the region. The proximity of much of Southeast Asia's land to the seas means that the effects of climate change are predicted to vary widely across the region (Christensen et al. 2013); however, the dry season in two areas with particularly large expanses of peatlands—southern Sumatra and southern Borneo—is expected to become even drier in the coming years (Christensen et al. 2013; Li et al. 2007).

Even more concerning, recent observations have shown that drought years are no longer a necessary precursor to major haze events resulting from the clearing of peatlands. Even small changes in rainfall have disproportionately large impacts on emissions of particulates from fire (van der Werf et al. 2008), and climatic changes, continued deforestation, and continued drainage of peatlands will therefore likely cause increasingly frequent haze events in future years (Gaveau et al. 2014). In 2013, a year with neither positive Indian Ocean dipole nor ENSO conditions, the region saw record-setting haze, quite possibly a harbinger of the region's future (Gaveau et al. 2014).

Consequences of Smoke and Haze Pollution for Residents' Health

During haze episodes, many residents of Southeast Asia are exposed to a complex mixture of pollutants, including highly



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While widely used during haze events, surgical masks, such as this one donned by a woman in Singapore, provide inadequate protection. They do not filter out the small particles that make haze so dangerous.

elevated levels of particulate matter. Residents of Indonesia, Singapore, and Malaysia are most often affected because of their proximity to the fires. Increases in short-term exposure to particulate matter can have immediate health effects, most evident in populations already at risk, while long-term exposure increases the risk of cardiovascular and respiratory diseases for the entire population (Brook et al. 2010; WHO Europe 2006).

IMPACTS OF HAZE ON AIR QUALITY

Air quality is affected by many sources of pollution, including agriculture, transportation, and stationary sources such as factories. Throughout Malaysia, air quality is generally good, posing little or no risk to health (Afroz et al. 2003). However, while total emissions from transportation and stationary sources are relatively constant, during a heavy haze episode caused by agricultural burning, the air quality in Kuala Lumpur, for example, is much worse, often reaching levels that pose serious health concerns (Afroz et al. 2003). Agricultural burning is to blame for much of the health-threatening air quality; when air quality measurements in the region are averaged over the course of the year, it is only because of the emissions from these fires that air quality in the region does not meet World Health Organization recommendations (Marlier et al. 2013).

Landscape fires burning biomass produce smoke and haze containing hundreds of chemicals. A significant number of these are health-damaging pollutants (Johnston et al. 2012; Naeher et al. 2007), and the mixture found near fires is different from those found farther away—therefore, exposures and potential health effects vary by distance from the fire. These pollutants include particulate matter (composed mainly of organic and black carbon), carbon monoxide, methane, benzene, mono-nitrogen oxides, carbon dioxide, methanol, and dimethyl sulfide (Naeher et al. 2007; Usup et al. 2004; Aditama 2000). Most studies have examined the health effects of the entire mixture using fine particulate matter as a proxy (particles measuring 2.5 micrometers and less), because it is both the best metric for exposure and generally the most dangerous pollutant (Johnston et al. 2012; Naeher et al. 2007; Kunii et al. 2002; Ostermann and Brauer 2001; WHO 1999). Smaller particles are more hazardous because they penetrate more deeply into the lungs and persist for longer in the atmosphere (Naeher et al. 2007; Frankenberg et al. 2005; WHO 1999). Particles from burning vegetation and other biomass are relatively tiny—generally smaller than 1 micrometer (Naeher et al. 2007; Ostermann and Brauer 2001). Particles as small as 1 micrometer easily infiltrate indoor air, making exposure unavoidable even for people who remain inside (Kunii et al. 2002; WHO 1999). These tiny particles settle out of the atmosphere very slowly and are easily transported by winds over long distances (Andreae et al. 1988), as seen when haze from Indonesia reaches Singapore, Malaysia, Brunei, and sometimes hundreds of miles to the Philippines and Thailand.

During the El Niño years of the late 1990s and early 2000s, up to 11 percent of the population in Southeast Asia was exposed—repeatedly—to levels of particulate matter from fires well above what is considered safe by the World Health Organization (Marlier et al. 2013). These guidelines set the limit for fine particulate matter at an average of 25 micro-

These photos, looking toward Marine Parade Road in Singapore, compare the haze conditions on June 21, 2013, to the clear conditions on June 24, 2013. The June 2013 haze event was particularly acute, severely limiting visibility in the region.

World Health Organization Air Quality Guidelines for Particulate Matter

	PM10 (μg/m³)	PM2.5 (μg/m³)
24-hour Mean	50	25
Annual Mean	20	10

Haze in the region frequently pushes particulate matter levels well-above what is recommended by the World Health Organization. At a point in time in October of 1997, levels of PM10 in Jambi City, Indonesia were measured at 1864 μg/m³ (Kunii et al. 2002). During that same event, average monthly PM10 values in Singapore, normally are around 30–50 μg/m³, were elevated to 60–100 μg/m³ for September and October (Emmanuel 2000).

Note: PM10 refers to particles of 10 micrometers or less, and PM2.5 refers to particles of 2.5 micro-meters or less. μg/m³ is microgram per cubic meter.

SOURCE: (WHO 2006).

grams per cubic meter (μg/m³) over a 24-hour period (see the table). During these years, air measurements near fire sources increased by 50 to 200 μg/m³ because of the fires, with associated effects on health (Marlier et al. 2013).

During extreme haze episodes, residents sometimes cover their mouths with surgical masks or cloths. But these makeshift solutions are not adequate protection; they do not filter out the smallest and most damaging particles in the haze (Ministry of Health 2014; WHO 1999). Instead, health authorities advise residents to limit physical exertion and remain in indoor spaces with filtered air, such as air-conditioned rooms, as much as possible (WHO 1999); however, these recommendations are not feasible for many residents who do not have access to spaces with filtered air.

IMPACTS OF HAZE ON RESIDENTS' HEALTH

During past haze events, populations in the most commonly affected countries of Indonesia, Singapore, and Malaysia have experienced adverse health impacts of varying severity, influenced in part by distance from fires, access to filtered air, and access to health care. The majority of people exposed to haze may experience either no effects or acute (immediate and often temporary) health effects with mild symptoms, such as eye and skin irritation (WHO Europe 2006; Aditama 2000); however, some people experience more serious effects on their respiratory and cardiovascular systems (Figure 2).

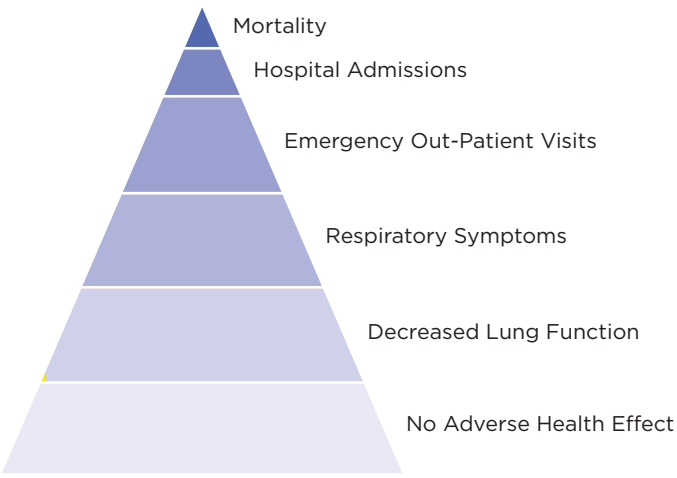
ACUTE HEALTH EFFECTS

Populations closest to the fires are often highly impacted. In a study of the impacts of a 1997 haze event on the population of Jambi City, Indonesia (a city very close to the fires), more than 90 percent of respondents reported some level of respiratory problem (Kunii et al. 2002). A government report found a marked increase of 51 percent in respiratory disease in Jambi during the same haze event (Aditama 2000). These and other studies show the magnitude of haze-related health impacts on exposed populations.

Because of the region's compact geography, residents in Malaysia are also heavily affected by haze. According to data gathered during 2005, 2006, 2008, and 2009, the number of daily inpatient visits rose by 31 percent on hazy days in Kuala Lumpur and the immediate surrounding region (Othman et al. 2014). Outpatient visits also rose: in September of 1997 in Kuching (in the Malaysian state of Sarawak), outpatient visits increased by 200 to 300 percent during peak periods of haze (Sastry 2000). People with existing health conditions were heavily impacted as well. In 1997 in a hospital in Kuala Lumpur, daily outpatient visits of people with respiratory disease increased by 320 percent during the peak of the haze event (Sastry 2000).

These health effects stand in stark contrast to those in Singapore, where residents have greater access to health care and filtered air. Average monthly values for particulate matter doubled in the autumn of 1997 in Singapore, and while there was a 30 percent increase in outpatient medical care due to haze-related conditions, neither hospital admissions nor mortality increased significantly, and the overall health impacts in the country were mild (Emmanuel 2000).

FIGURE 2. Health Effects of Haze Exposure



As is illustrated in the figure above, the majority of the population exposed to haze from landscape fires experience no or only mild effects. However, for a minority of the population, the effects can be much more severe, requiring hospital admission and sometimes resulting in death.

SOURCE: SCHWELA ET AL. 1999.

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Firefighters, along with outdoor workers and first responders, are at high risk of health complications from landscape fires due to their exertion and proximity to smoke. Pictured are villagers in a fire drill in Palangkaraya, Central Kalimantan, Indonesia.

CHRONIC HEALTH EFFECTS

Haze occurs regularly in Southeast Asia and can last for long periods of time. Most of the research on air pollution and health consists of studies of short-term exposure or annual exposure, neither of which captures the episodic haze events in Southeast Asia (Johnston et al. 2012). However, it is clear that this chronic exposure can have lasting effects on cardiovascular health and is likely linked to long-term respiratory effects (Johnston et al. 2012; Brook et al. 2010; EPA 2009; WHO Europe 2006).

Smoke from burning biomass contains chemicals classified as known human carcinogens by the International Agency for Research on Cancer, a division of the World Health Organization (Naeher et al. 2007). Results from a recent study on the health risk of particulate-bound carcinogenic and non-carcinogenic metals from peat fires suggested that inhalation exposure to these metal emissions poses serious cancer and non-cancer health threats to individuals very near to the fires and non-metal components of the smoke pose additional risk. Those individuals include plantation workers, firefighters, and those living nearby (Betha et al. 2013).

MORTALITY

A small minority of people experience severe impacts from the haze, and mortality due to respiratory or cardiovascular stress (or both) has been well documented among both fragile and hardy populations. Each year around 110,000 deaths associated with particulate matter exposure in Southeast Asia can be attributed to the fires (Johnston et al. 2012).

In Malaysia, for residents of the region surrounding Kuala Lumpur, particularly hazy days between 2000 and 2007 were responsible for an immediate increase—19 percent—in mortality from respiratory causes. Women were more likely to experience delayed effects, with the highest rate of respiratory mortality occurring five days after a haze event. In addition, mortality from respiratory problems increased by 66 percent for typically vigorous people, those aged 15 to 59 (Sahani et al. 2014). Prenatal exposure to

particulate matter has been linked with low birth weight, pre-term delivery, and fetal death (Holstius et al. 2012; Jayachandran 2009; WHO Europe 2006).

There is also evidence that haze increases cardiovascular mortality, such as from heart attacks. In Kuala Lumpur, the risk of cardiovascular mortality for individuals aged 65 to 74 doubled on days following a haze episode (Sastry 2000). For adults over 30 years old, high-haze years were estimated to increase cardiovascular deaths by around 10,800 (about 2 percent) because of particulate matter exposure (Marlier et al. 2013).

Each year around 110,000 deaths associated with particulate matter exposure in Southeast Asia can be attributed to the fires.

Finally, years with more fires and greater haze are estimated to have higher mortality overall. During the strong El Niño episode in 1997 and 1998, the modeled annual mortality in Southeast Asia attributable to landscape fires more than doubled as compared to the 10-year average—by around 186,000 additional deaths (Johnston et al. 2012). The magnitude of this increase underscores how even relatively small changes in climate can have disproportionately large impacts on emissions from landscape fires, with implications for the future of the region and the health of resident populations (van der Werf et al. 2008).

HEAVY BURDEN ON AT-RISK POPULATIONS

Some groups of people are at a greater risk than others of the health impacts associated with exposure to haze from landscape fires. These vulnerable populations include individuals with pre-existing respiratory or cardiac diseases, the very young and old, pregnant women, and those performing physical labor (Naeher et al. 2007; WHO Europe 2006; Aditama 2000; WHO 1999). Children have faster breathing rates, are often more physically active, are more likely to spend time outdoors, and have developing airways that are more susceptible to inflammation (Griscom et al. 1978). To help reduce risk during haze events, the World Health Organization recommends that schools, childcare centers, retirement centers, nursing homes, hospitals, and hospices take extra care to provide spaces where the air is filtered (WHO 1999). Residents are advised to limit physical exertion and remain in indoor spaces with filtered air as much as possible (WHO 1999).

The health consequences of landscapes fires also fall heavily on the poor. Mortality associated with these fires is higher in low-income regions of the world (Johnston et al. 2012). In the autumn of 1997, haze pollution doubled, and the estimated fetal and child mortality in Indonesia was much higher in poor districts than in wealthier districts (Jayachandran 2009). And these estimates are likely low, since low-income individuals are less able than middle- and high-income individuals to access the health system or afford medical care, making it likely that many of their health problems go undocumented.

Economic Costs and Other Consequences of Haze

While the greatest economic impacts of fire and haze episodes are related to health care costs, there are also losses related to tourism and economic productivity, as well as disruptions to residents' everyday lives.

HEALTH COSTS

Economists have attempted to quantify the costs of the health impacts due to haze, and because of its intensity and duration, the 1997–1998 haze event has been the most thoroughly studied. In analyses covering just the 1997 portion of this haze disaster, the health care costs in Malaysia were estimated at around $12 million (2012 USD) and between $5 and $17 million in Singapore (2012 USD) (Quah and Johnston 2001; Hon 1999; Shamwahid and Othman 1999). The Indonesian health-related costs of this event are much higher, but estimates vary widely based on differences in methodology. One study covering the costs of both the 1997 and 1998 haze estimated the costs to be around $199 million (2012 USD); another looking only at 1997 estimated costs at around $1.8 billion (2012 USD) (BAPPENAS 1999; Ruitenbeek 1999).

BROADER ECONOMIC COSTS AND DISRUPTION

The 1997–1998 haze episode gives a clear picture of the scale of possible future economic impacts of increasingly likely major haze events. According to the studies examining the effects of the 1997 portion of the haze event, losses related to health, tourism, transportation, industrial production, fishing, and cloud seeding cost the economies of Indonesia, Malaysia, and Singapore an estimated total of $2.6 billion (2012 US dollars) (Schweithelm et al. 1999). Other studies report costs from the 1997 fires and haze at around $4.5 billion, and for

> ***Almost 2.5 million work days were lost between September and November of 1997 because of haze exposure in eight Indonesian provinces.***

both 1997 and 1998 at $9.3 billion (Barber and Schweithelm 2000). These latter estimates include losses in timber, agriculture, and carbon.

In Indonesia, short-term health costs represented by far the largest category of costs (Figure 3). In Malaysia, losses from industrial production showed the greatest impact, while Singapore's costs were mostly related to tourism. Other areas that incurred serious costs were transportation and emergency response and the regular operation of schools and businesses.

Transportation losses were caused mostly by poor visibility that affected land, sea, and air transportation. More than 3,000 flights were canceled in Indonesian Sumatra and Kalimantan (Aditama 2000), and the haze caused transportation slowdowns and contributed to deadly accidents, such as a plane crash in Sumatra and a boat collision in Kalimantan (Frankenberg et al. 2005; Barber and Schweithelm 2000). The canceled flights had an impact on tourism more broadly, most notably in Singapore where tourism losses were by far the most significant economic impact (Schweithelm, Jessup, and Glover 1999).

Heavy haze also closed schools and businesses (Frankenberg et al. 2005). In Malaysia, a 10-day-long state of emergency in the state of Sarawak allowed the operation only of essential activities such as sales of food, delivery of electricity and water, and law enforcement (Shahwahid and Othman 1999). Almost 2.5 million work days were lost between September and November of 1997 because of haze exposure in eight Indonesian provinces (Barber and Schweithelm 2000). And finally, there are the direct costs of fighting the landscape fires—from employing firefighters and purchasing and maintaining equipment to taking measures to increase precipitation with cloud seeding.

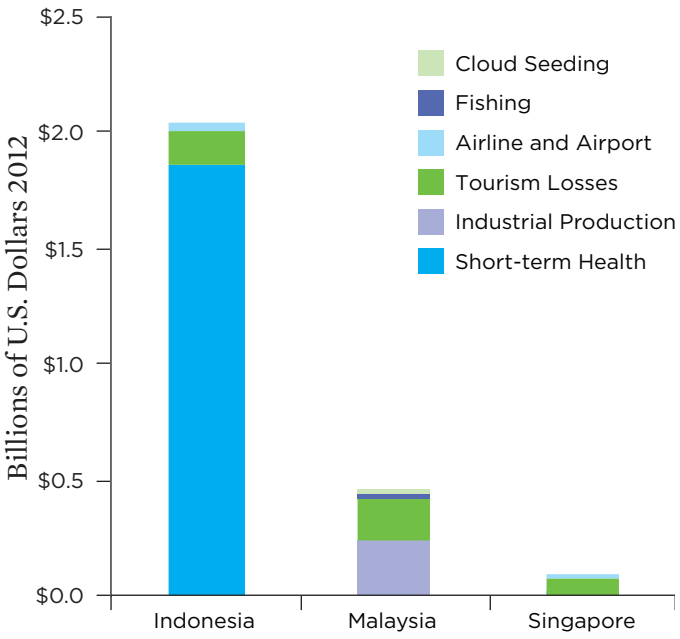
The diversity and extent of these costs illustrate that, while the palm oil industry brings revenue and jobs to producing nations, it is not without serious impacts and costs to human health as well as to multiple sectors of the economies of nations in the region.

DIPLOMATIC COSTS: INTERNATIONAL RELATIONSHIPS AND NEGOTIATION

With such heavy economic losses and health impacts, these haze episodes have become a source of contention within the international community, and efforts to curb their detrimental effects have complicated the diplomatic relations in the region (Sastry 2000). In 2002, the Association of Southeast Asian Nations (ASEAN)—Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam—convened to create an accord on haze pollution crossing international boundaries, known as the ASEAN Agreement on the Transboundary Haze Pollution. The agreement calls for parties to develop practices to prevent, monitor, and mitigate haze pollution that crosses international borders and created a coordinating center to facilitate cooperation and information-sharing. However, the agreement had limited impact for years because Indonesia did not sign on as a full partner. It finally ratified the treaty in September of 2014.

Meanwhile, Singapore enacted a law that goes even further. In 2014, Singapore passed the Transboundary Haze

FIGURE 3. 1997 Haze-related Damages



While short term health care costs in the region were significant, a number of other costs affected national economies. In Malaysia, losses in industrial production were the most damaging, and the economic impact to Singapore was largely related to tourism.

SOURCE: ADAPTED FROM SCHWEITHELM ET AL. 1999.

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Tourism in Indonesia, Malaysia and Singapore can be severely impacted by haze events, as flights are cancelled, marine transportation is halted, and businesses, like this night market in Malaysia, close.

Pollution Act, an effort to hold entities (such as corporations or even individuals) liable for any involvement in landscape fires polluting Singapore's air (Parliament of Singapore 2014). The law is especially notable in that it proposes to hold these entities responsible for haze even if the haze originates in areas outside of Singapore. A corporation could be charged with a criminal offense and fined for burning areas, even those in other countries, if that burning affects air quality in Singapore. In addition, the law allows any person or business who sustains physical injury, damage to personal property, or other economic loss from haze to bring suit against responsible parties. The international implications of this law may make its implementation difficult, but its strong penalties for bad actors could go far toward holding parties responsible for adverse health and/or economic impacts.

The Southeast Asian media recognize the links between palm oil, peat soils, haze, and the associated health effects, and newspaper articles about the fires and haze in 1997, 2005, and 2013 show an evolution in coverage. Initially, reporting focused on potential health and economic impacts, and at least partially attributed the effects to El Niño. Increasingly, however, reports have focused on Indonesia's (prior) refusal to sign the ASEAN Agreement on Transboundary Haze Pollution and private companies' investments in oil palm plantations (Forsyth 2014).

Singapore's statutory ability to hold entities responsible for haze and Indonesia's ratification of the agreement to cooperate on the prevention and response to large fires both constitute new tools to combat haze pollution in the region. At the very least, continued media coverage will help to ensure that, should these new tools prove to be insufficient, there will continue to be visibility and public demand for an end to this practice that brings such public health and environmental damage.

Recommendations for Ending the Health- and Economy-Damaging Pollution

Land-clearing and agricultural production techniques that cut down forests, drain peatlands, and use fire as an inexpensive tool for clearing land all exacerbate the effects of the dry season in Southeast Asia and put the health of millions of residents at risk. Haze from landscape fires shuts down businesses, reduces tourism revenue, and increases health care costs. Reducing fires over the long term is critical.

Reducing the risk of fires and haze will require a concerted effort on the part of many different actors. Most notably needed is the creation of a global demand for deforestation- and peat-free palm oil production that does not contribute to flammable landscape conditions. Recent actions by consumer companies worldwide to enact policies to purchase only palm oil produced without the destruction of forests or peatlands demonstrate the potential for this market. Continued progress depends on the actions of many more:

- **Consumers** of the thousands of products that contain palm oil need to continue to let manufacturers know that palm oil grown on plantations free from deforestation and peatland degradation is important to them.
- **Companies** using palm oil in their products should be able to verify that the palm oil they use does not contribute to deforestation or peatland degradation. They should also take the necessary steps to protect their brands by ensuring that the palm oil used in their products do not originate on land where fires occurred.
- **Commodity traders**, an important link in the palm oil supply chain, must commit to trade only in palm oil coming from plantations that are free from deforestation and peatland degradation, and where fires do not occur. Already a few major traders of palm oil have made these commitments, lowering their risk for being implicated as a source of the debilitating haze.
- **Investors** should protect their interests by financially supporting only those businesses that take the necessary steps to limit this public health crisis. This will send a strong signal to the market that unsustainable production practices are not acceptable. It will encourage oil palm growers to sustainably expand operations by increasing yields and expanding onto lands that do not contain forests or peat.
- **Governments** should invest in monitoring and enforcing existing bans on the use of fire as a method for land preparation. This is particularly important during the dry season, especially in those years predicted to be affected by the naturally occurring climatic conditions that lead to drought conditions—years of El Niño or positive Indian Ocean dipole—since enforcement during those times is critical. Governments can support one another in this effort, with those nations concerned about tropical forest preservation providing funding for monitoring and enforcement.

Already millions of people have suffered grave damage to their health because of the haze created by oil palm production practices. Given the predicted increase in conditions favorable to haze and a growing population in the region, the potential for increasingly devastating effects on the economy and public health is very real. It is more important than ever to minimize the human contribution to landscape fire and haze events—and ultimately prevent their negative health and economic impacts—by eliminating the use of fire for site preparation, deforestation, and peatland destruction and by transforming palm oil production practices, moving toward methods that protect the environment and human health.

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