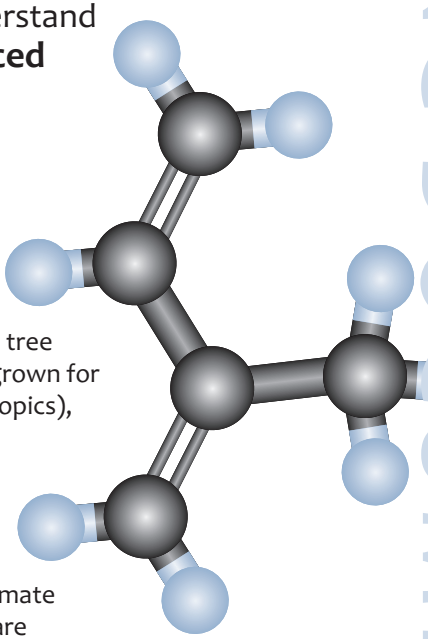
ISOPRENE

MANAGING ITS ENVIRONMENTAL IMPACT

BRIEFING DOCUMENT

Isoprene is a **natural** volatile compound produced in **vast quantities** by many organisms, but **especially by plants**.

3 **Three Reasons** why those responsible for the governance of the **environment**, **agriculture** and **forestry** should understand how **isoprene** is **produced** and **consumed**:



- As much **isoprene** is liberated into the atmosphere as the greenhouse gas, methane.
- Big producers of **isoprene** include tree crops that are increasingly being grown for biofuels (such as palm oil in the tropics), and for biomass (such as poplar and willow in temperate regions).
- **Isoprene** is highly reactive in the atmosphere and so impacts on climate and health in complex ways that are detrimental if not carefully managed.

This document provides background information about isoprene that will support practitioners and policy makers to minimise its potentially damaging effects on the environment.

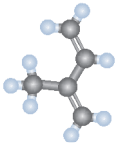
IMPORTANCE & ABUNDANCE OF **ISOPRENE**

Isoprene is a natural, volatile chemical that readily reacts with other compounds in the atmosphere, and so affects climate and human health. The metabolic pathway that leads to the formation of **isoprene** is also responsible for making thousands of important biological molecules, such as vitamin A, rubber, as well as pine and lemon scents.

Each year, approximately **500 million tonnes of isoprene** (roughly the mass of 1500 Empire State Buildings) is liberated into the atmosphere. This is similar to the flux of the greenhouse gas, methane, and is more than any other natural volatile organic compound. In heavily forested areas, **isoprene** can impart a **blue haze**, which gives rise to the names of the Blue Mountains (Australia) and Blue Ridge Mountains (USA).

WHAT PRODUCES **ISOPRENE** & WHY?

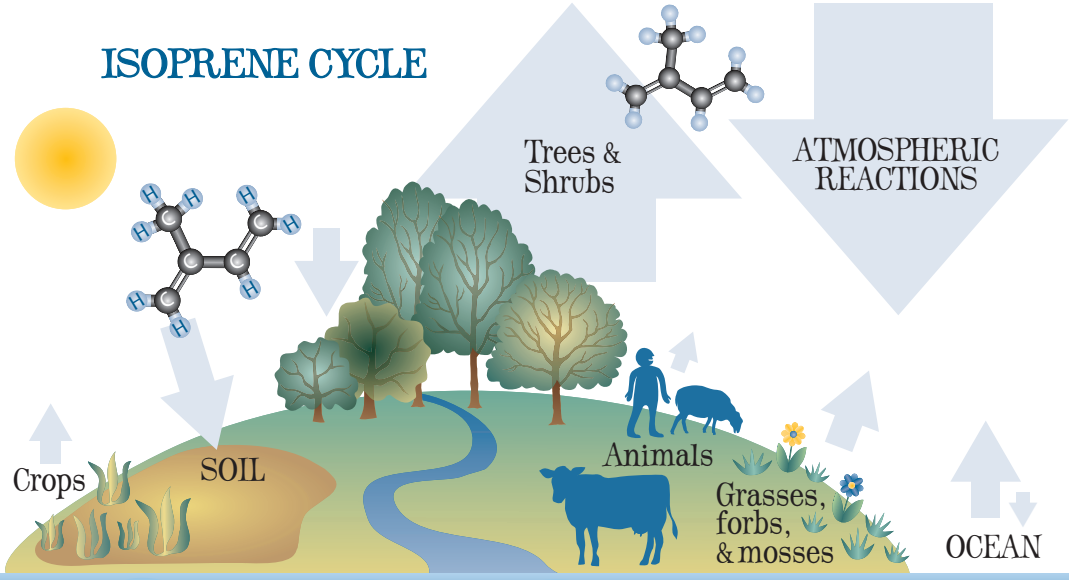
Trees produce most isoprene, but it is also produced by other plants, mosses, bacteria, fungi and animals (including humans). In the marine environment, photosynthetic algae are primarily responsible for isoprene production.



Isoprene production allows plants to defend themselves against stresses, especially heat stress and oxidative stress. Isoprene is produced in abundance by many tree species as a means of rapid protection from large fluctuations in temperature, for example caused by the sun appearing from behind clouds. Isoprene has also been shown to serve as a signalling molecule.

Importantly, **there is a lot of variation** in the amount of isoprene produced by plants; some species of oak are major isoprene producers, while other species of oak do not produce isoprene.

ISOPRENE CYCLE



IMPACTS OF **ISOPRENE** ON THE ATMOSPHERE

Isoprene is highly reactive and so its effects on the chemistry of the atmosphere are often indirect, complex and determined by the abundance of other atmospheric chemicals. Here we outline some of those effects:

- **Free radicals** remove methane from the atmosphere. However, isoprene is much more reactive than methane, and so will deplete the free radicals thereby prolonging methane's damaging greenhouse effect.
- **Isoprene reacts** with other atmospheric chemicals, including NOx (nitrogen oxides), resulting in the production of low-level ozone that is a greenhouse gas and damaging to the health of animals (including humans) and plants.
- **Isoprene production** results in the formation of secondary organic aerosols, which can have both beneficial and damaging effects. The beneficial effects arise because the aerosols seed cloud formation, reflecting sunlight and cooling the earth. However, the aerosols can lead to respiratory problems in humans.

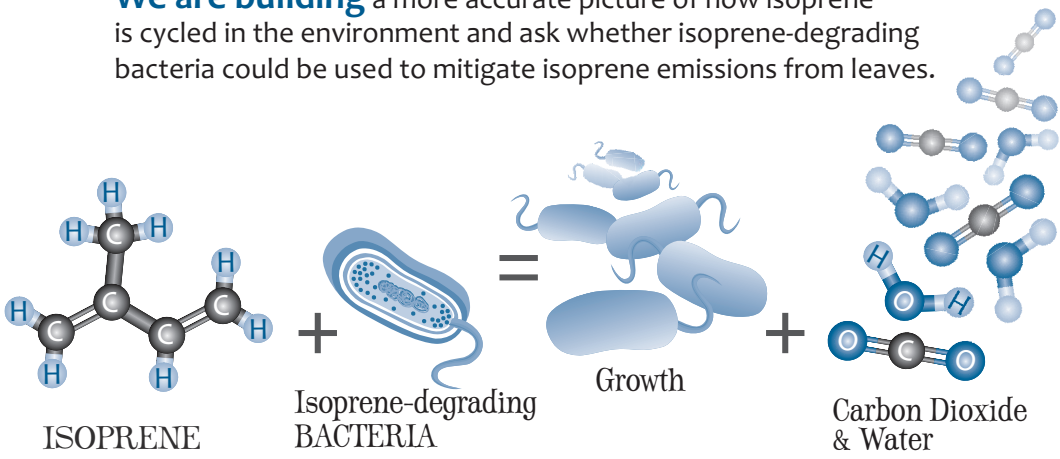
MICROBIAL CONSUMPTION OF **ISOPRENE**

Microbes provide many ecosystem services that sustain life on earth. One key microbial function is the consumption of methane, which reduces its atmospheric concentration, a process that has been the subject of many hundreds of scientific papers.

Microbes also consume isoprene, but to date there are a handful of published studies on this phenomenon. Our research builds on this foundation, and has found the following:

- **Microbes** in soil consume isoprene rapidly
- **Microbes** in marine environments also consume isoprene
- **Isoprene-degrading microbes** are present on leaf surfaces
- **Many different species of bacteria** degrade isoprene, but the main microbes responsible belong to the group called *Rhodococcus*
- **We now have an intricate understanding** of the genes that allow bacteria to grow on isoprene, and how they are regulated

We are building a more accurate picture of how isoprene is cycled in the environment and ask whether isoprene-degrading bacteria could be used to mitigate isoprene emissions from leaves.



ISOPRENE & environmental governance Problems

Major producers of isoprene include tree crops that are increasingly being grown for biofuels (e.g. palm oil in the tropics) and biomass burning (e.g. poplar, eucalyptus and willow in temperate regions). These tree crops often replace food crops that emit relatively low levels of isoprene.

Isoprene's most damaging effects occur in the presence of NOx, which largely derive from car exhausts or some microbial processes (especially when a lot of nitrogenous fertiliser is applied).

According to one published estimate, if the EU is to meet its 2020 target for fuel coming from biological sources (by growing biomass crops), there will be an additional **1365 deaths and $8.6 billion in economic loss per year** (DOI: 10.1038/NCLIMATE1788).

Therefore, the wider implications of cultivating crops for generating energy must be considered along with their potential to save carbon.

ISOPRENE & environmental governance Solutions

The following strategies should be considered:

- **Restrict planting** to areas where isoprene is less likely to generate ozone (e.g. far from cities), and adapt or remove any fertilisation regime
- **Judiciously select** natural low-emitting cultivars and / or plants that have been genetically modified to produce little or no isoprene
- **Potentially inoculate plants** with cultivated isoprene-degrading microbes

Each strategy has shortcomings and further research in this new field will accelerate the process of finding viable solutions.

This document provides information about ***one*** problem caused by ***one*** biologically produced volatile organic compound. In fact, many volatile compounds, emitted from land and sea, impact on our climate, and are consumed, and sometimes produced, by microbes. We require an improved understanding of the natural cycles of these volatile compounds, how human activities alter their flux, and strategies to mitigate detrimental changes.

Resources

http://www.**isopreneresearch**.com/
http://www.es.lancs.ac.uk/people/cnh/**UrbanTrees**Brochure.pdf
http://www.microbiologysociety.org/publications/policy-docs.cfm/publication/**food-security-from-the-soil-microbiome**
http://www.microbiologysociety.org/publications/policy-docs.cfm/publication/**microbiology-and-climate-change**
http://www.es.lancs.ac.uk/cnhgroup/**iso-emissions**.pdf

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