
# Negotiation-support toolkit for learning landscapes

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# 27 | Re-assessing oxygen supply and air quality (ROSAQ)

**Meine van Noordwijk and Betha Lusiana**

A storyline that remains popular in public discourse and policy making is that trees provide oxygen. While scientists may argue that there is an excess rather than shortage of oxygen in the atmosphere, there are important issues of air quality that trees and forests interact with. The Re-assessing Oxygen Supply and Air Quality (ROSAQ) tool provides some pointers to how these can be tackled as part of a landscape approach.

## Introduction

Tropical forests are often portrayed as the lungs of the world. Lungs of humans (common with all animals) interface with the atmosphere by reducing its oxygen and increasing its carbon-dioxide content (so forests might be the 'anti-lungs' rather than the lungs of the world). Among the positive roles of trees (and other vegetation) we often see 'provisioning of oxygen'. While technically correct (at least during the daytime in the growing season), this provisioning does not qualify as an 'ecosystem service' because these are based on 'benefits people derive from'. With over 20% of the global atmosphere consisting of oxygen—which plays a major role in fire events—there is no shortage of the gas. Even within closed buildings the purported 'lack of oxygen' is rather an excess of other gasses that have accumulated. Opening windows is the easiest way to solve that issue and provide the desired environmental service.

Yet, trees that are strategically placed do play important functions with respect to air quality. The ROSAQ tool was designed to shift the frequently asked questions about air quality into an exploration of the three interacting knowledge domains: local, policy-makers' and modellers' ecological knowledge, as used in other tools.

## Objectives

Contribute to the identification of realistic roles of strategically placed trees and forests in improving air quality, while responding to commonly repeated concerns about oxygen supply.

**Table 27.1.** Air pollutants can affect air quality in many ways

| Pollutant (http://en.wikipedia.org/wiki/Air_pollution) | Mechanism by which trees and forests may interact with the pollutant |
|---|---|
| Particulates, alternatively referred to as particulate matter, atmospheric particulate matter or fine particles, are tiny particles of solids or liquid suspended in a gas. In contrast, 'aerosol' refers to particles and the gas together. Sources of particulates can be human-made or natural. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols. Averaged over the globe, anthropogenic aerosols—those made by human activities—currently account for about 10% of the total amount of aerosols in our atmosphere. | Deposition depends on wind speed, so effects of trees and tree rows on turbulence can influence local deposition. |
| Sulfur oxides (SOx), especially sulfur dioxide, a chemical compound with the formula $SO_2$. $SO_2$ is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulfur compounds, their combustion generates sulfur dioxide. Further oxidation of $SO_2$, usually in the presence of a catalyst such as $NO_2$, forms $H_2SO_4$, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources. | Wet leaf surfaces, for example, of trees, can lead to enhanced deposition of ammonium sulfate. Although trees thus clean the air, they may suffer from the 'acid rain' effect of this deposition. |
| Ammonia ($NH_3$) is emitted from agricultural processes. Ammonia is a compound with the formula $NH_3$. It is normally encountered as a gas with a characteristic pungent odour. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilisers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous. | |
| Nitrogen oxides (NOx), especially nitrogen dioxide, are expelled from high temperature combustion and are also produced naturally during thunderstorms by electrical discharge. Can be seen as the brown haze dome above or plume downwind of cities. Nitrogen dioxide is a chemical compound with the formula $NO_2$. It is one of the several nitrogen oxides. This reddish-brown toxic gas has a characteristic sharp, biting odour. $NO_2$ is one of the most prominent air pollutants. | Leaves with wet surfaces and open stomata can absorb some nitrogen oxides on their way to the atmosphere. |
| Carbon monoxide (CO) is a colourless, odourless, non-irritating but very poisonous gas. It is a product of incomplete combustion of fuel, such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide. | |
| Volatile organic compounds (VOCs) are an important outdoor air pollutant. In this field they are often divided into the separate categories of methane ($CH_4$) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming. | Some tree-produced VOCs are implied in rainfall triggering as they form condensation nuclei for raindrops, potentially enhancing the air-clearing effect of rainfall. |
| Odors, such as from garbage, sewage and industrial processes | |

## Steps

### 1. Exploration of local ecological knowledge (LEK)

The LEK component is straightforward as there is likely some recognition of what constitutes 'fresh' air but no specific knowledge of individual gasses, such as oxygen. Components that may be explored deeper are 'dust', 'smoke', 'haze', 'bad smell'.

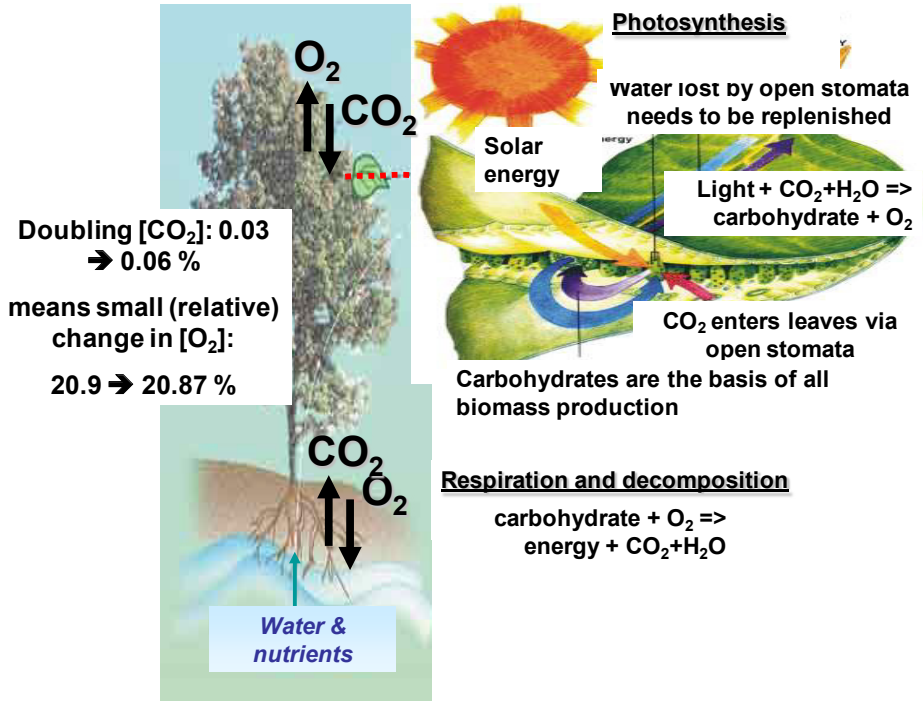


**Figure 27.1.** Leaf-level relationship between oxygen and carbon dioxide, with the consequences for both if the atmosheric $CO_2$ concentration doubles

### 2. Exploration of modellers' ecological knowledge (MEK)

Table 27.1 indicates possible mechanisms by which trees and forests can filter or increase deposition of air pollutants. Such effects have been documented for trees in urban environments but often require specialized equipment.

For oxygen, the MEK component is also straightforward. For example, the carbon dioxide ($CO_2$) emission estimates for Indonesia can be mole-per-mole converted to oxygen ($O_2$) consumption estimates (applying a factor or 32/44 for conversion), at least if we ignore the temporary storage in flows of organic products, which causes a time-lag between production and consumption of oxygen. The basic equation for photosynthesis (=>) and respiration/decomposition/fire (<=) is:

$$6CO_2 + 6H_2O + energy <=> C_6H_{12}O_6 + 6O_2$$

Because Indonesia is a net emitter of $CO_2$, its consumption of $O_2$ is greater than the $O_2$ that it produces. Spatial analysis can readily convert land-cover-change maps to $O_2$ consumption maps.

### 3. Exploration of policy-makers' ecological knowledge (PEK)

The PEK component is the most intriguing, as concerns over oxygen persist in the absence of evidence, or while the concepts are clearly challenged by science.

Air pollutant control, focused on point sources of industrial pollution, the domestic burning of organic fuel sources as well as biomass burning in relation to land use (and land-use change), has become a specialized part of environmental management. There is little explicit attention to filtering effects of trees and forests in most cases.

## Case study: Forestry Ministry asks Japan to check air quality

In 2008, Indonesia challenged Japanese scientists to check the balance between the amount of fresh oxygen produced by its protected forests and amounts of forest fire haze affecting neighbouring countries. This information could be an important way to counter repeated international protests over Indonesia's haze problems.

Indonesia has the largest forested area in the region, with some 120 million hectares of tropical forests. Annual forest fires causing massive amounts of air pollution prompted protests from the Singaporean and Malaysian governments. The president of Indonesia formally apologized to the country's neighbours for haze incidents in 2006, the second most severe after the 1997 haze disaster that blanketed Singapore and Malaysia.

Responding to the Ministry's request, a Japanese researcher said that it was difficult but technologically possible to calculate the amounts of smoke emanating from Indonesian forest fires. Rather than requiring new measurement techniques, the totals can be estimated from the reported carbon balance:

**Net effect on atmospheric oxygen supply = -32/44 X Net emissions of $CO_2$ to the atmosphere**

Unfortunately for the Ministry, the researcher concluded that Indonesia is, and will be, a net consumer (not producer) of oxygen until it becomes 'carbon neutral'.

The landscape scale is a meeting point for bottom–up local initiatives to secure and improve livelihoods from agriculture, agroforestry and forest management, and top–down concerns and incentives related to planetary boundaries to human resource use.

Sustainable development goals require a substantial change of direction from the past when economic growth was usually accompanied by environmental degradation, with the increase of atmospheric greenhouse gasses as a symptom, but also as an issue that needs to be managed as such.

In landscapes around the world, active learning takes place with experiments that involve changes in technology, farming systems, value chains, livelihoods' strategies and institutions. An overarching hypothesis that is being tested is:

> Investment in institutionalising rewards for the environmental services that are provided by multifunctional landscapes with trees is a cost-effective and fair way to reduce vulnerability of rural livelihoods to climate change and to avoid larger costs of specific 'adaptation' while enhancing carbon stocks in the landscape.

Such changes can't come overnight. A complex process of negotiations among stakeholders is usually needed. The divergence of knowledge and claims to knowledge is a major hurdle in the negotiation process.

The collection of tools—methods, approaches and computer models—presented here was shaped by over a decade of involvement in supporting such negotiations in landscapes where a lot is at stake. The tools are meant to support further learning and effectively sharing experience towards smarter landscape management.

World Agroforestry Centre
ASB Partnership for the Tropical Forest Margins
AARD
Federal Ministry for Economic Cooperation and Development
Norad
IFAD Enabling poor rural people to overcome poverty
CGIAR Research Program on Forests, Trees, and Agroforestry