



CML: Institute of Environmental Sciences



**Universiteit
Leiden**
The Netherlands



Discover the world at Leiden University.



Welcome

The Institute of Environmental Sciences (CML) is one of the leading global institutes in environmental sustainability. We are pleased to present the highlights of our work over the past year in this annual report. We hope you will enjoy it.

In 2016, we published over 90 papers, successfully crowdfunded the Living Lab project, celebrated a royal honour for associate professor Hans de Iongh and contributed to the Global Soil Biodiversity Atlas. We awarded five PhDs and taught students from all over the world how to contribute to sustainability.

We wish you a pleasant read.
CML staff, researchers and students

CML aims to contribute to the sustainable governance of biodiversity and natural resources worldwide

Research

CML has two research departments: Conservation Biology and Industrial Ecology.

Our Conservation Biology department studies the effects of human activities on the entire biological chain, while the Industrial Ecology department develops tools for decision-making on sustainable production and consumption.

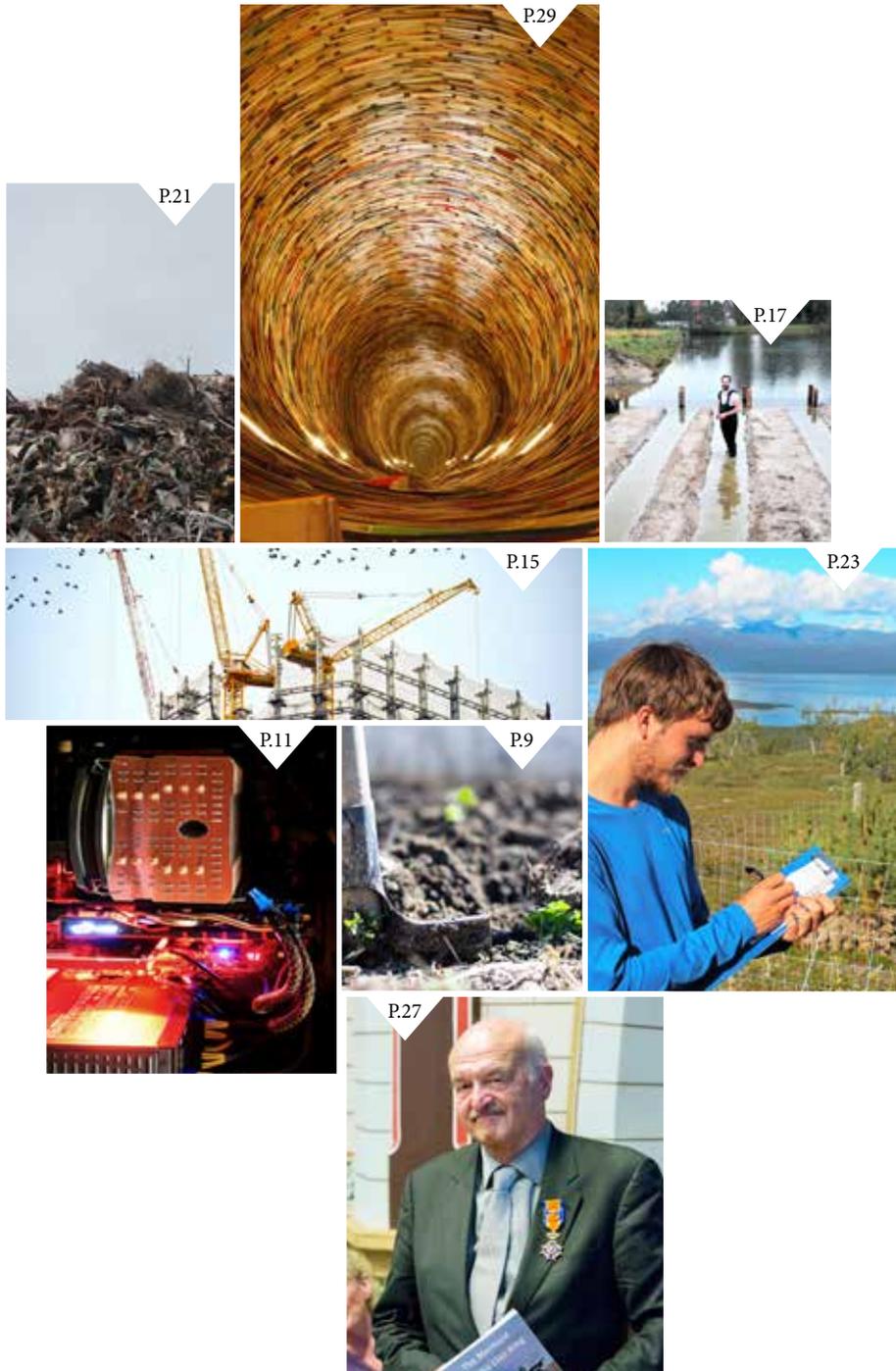
Our research is a balanced mix of fundamental and applied science for national and European science foundations, and contract research for clients such as the Dutch government and the private sector.

Education

CML's courses link science to societal issues and prepare students for a role in managing the world's natural resources and biodiversity. We offer a Masters in Industrial Ecology, a Minor in Sustainable Development, a Master specialization in Biodiversity and Sustainability, a popular open online course (MOOC) on the Circular Economy, and a PhD programme. During their time at CML, students work together in multidisciplinary groups using interactive learning methods.

- **1978**
CML was founded as part of Leiden University
- **2**
Research departments: Conservation Biology and Industrial Ecology
- **5**
Teaching programmes
- **5**
PhDs awarded in 2016
- **99**
Publications in 2016





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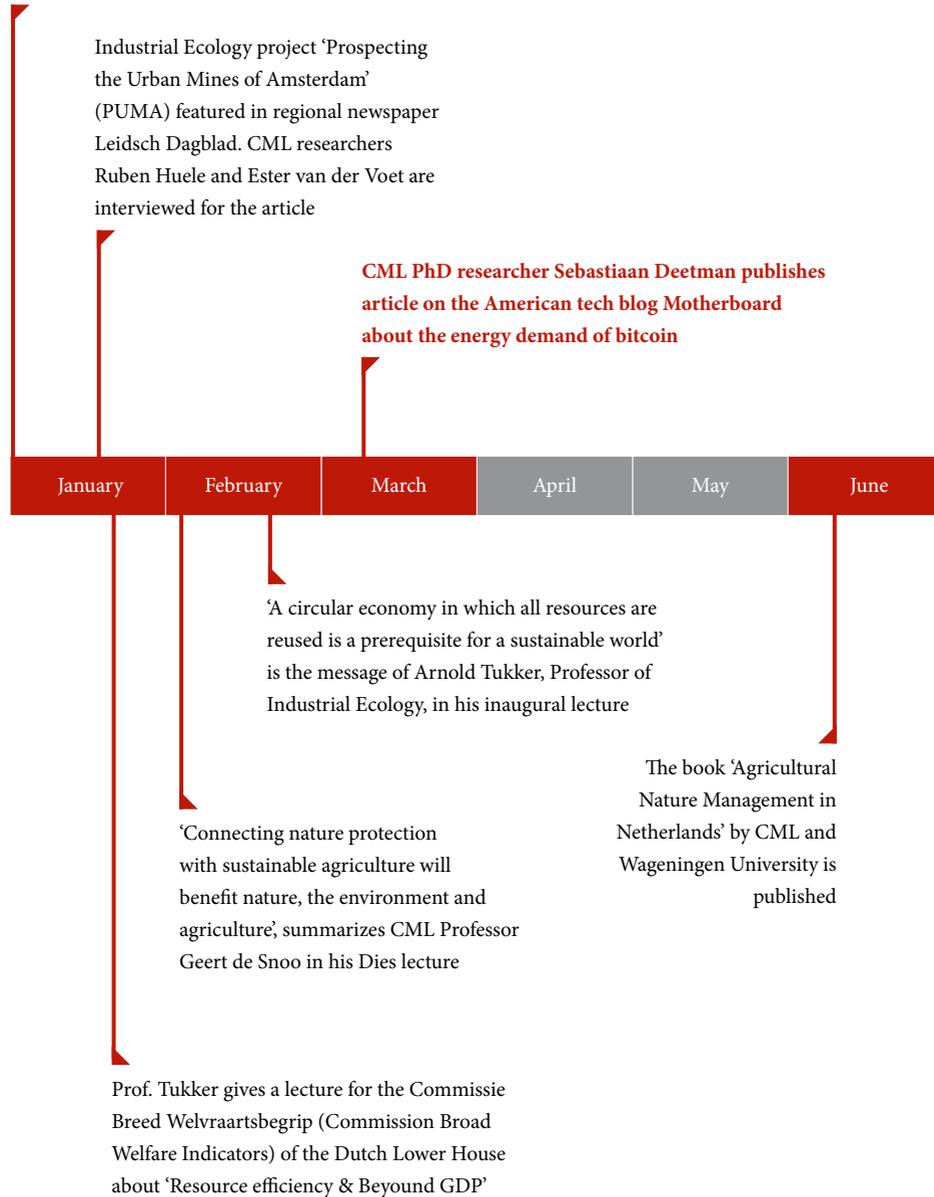
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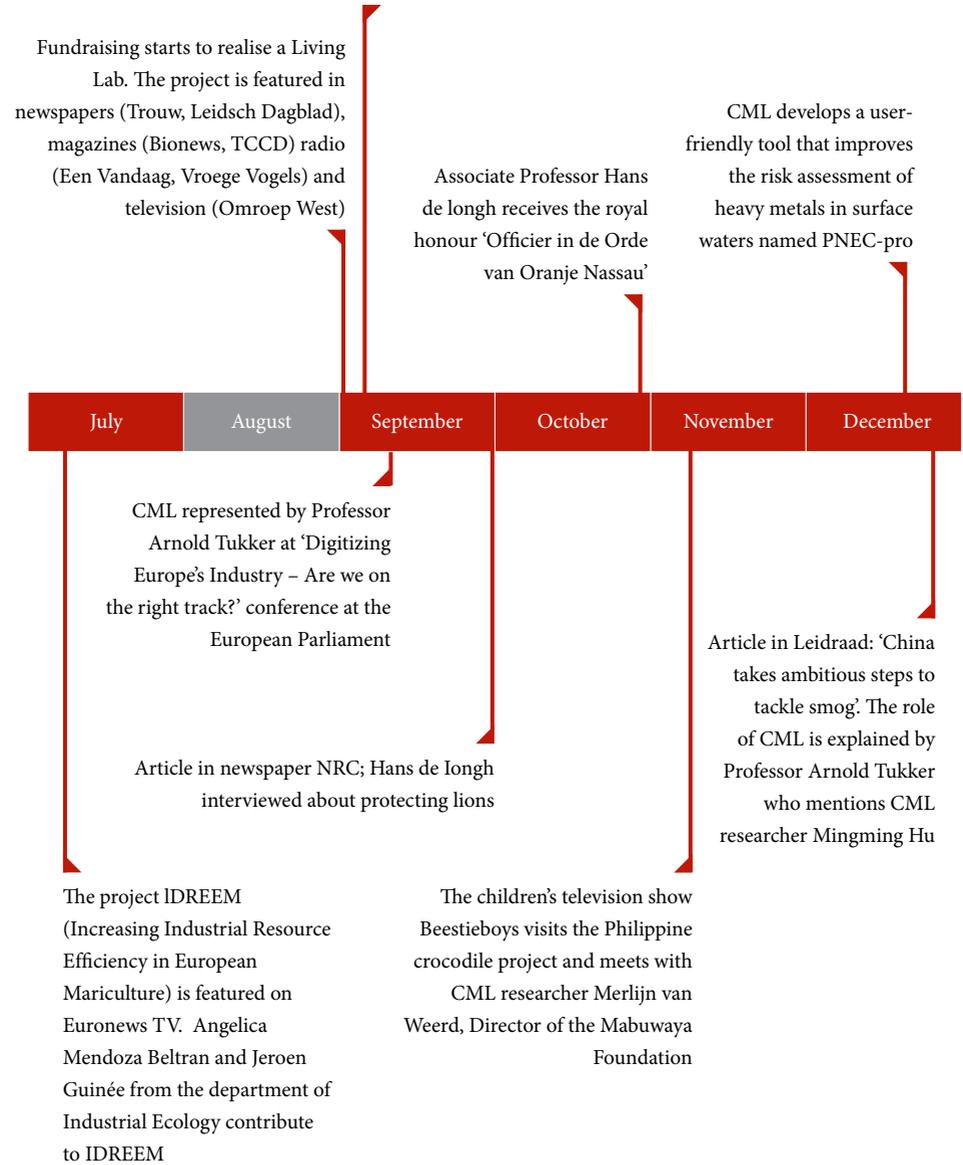
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Society 2016

Henrik Barmentlo and Arnold Tukker win prizes for societal impact



CML researchers Peter van Bodegom, Nadia Soudzilovskaia and Maarten Schrama contribute to the first ever Global Soil Biodiversity Atlas





CML contributes to Soil Biodiversity Atlas

Biodiverse soils are vital for human survival, but are often ignored in policy decisions

Soil biodiversity is increasingly under threat, even though it supports many services essential to humans such as plant growth, climate regulation, and disease control. To develop actions that preserve soil life, we need to better understand the consequences of soil biodiversity loss. That is why experts from all over the world have contributed to the Global Soil Biodiversity Atlas, including CML researchers Maarten Schrama, Peter van Bodegom and Nadia Soudzilovskaia.

Soil harbours an immense biodiversity: one teaspoon full of soil contains more than 5,000 taxa (species) of bacteria, fungi, nematodes and other organisms. Ecologists from all around the world have started exploring this huge biodiversity underneath our feet and produced the first Global Soil Biodiversity Atlas, started by the Global Soil Biodiversity Initiative and led by the Joint Research Centre of the European Commission. The maps are

far from complete, but the atlas shows which main groups of soil organisms can be expected where, and what their functions in ecosystems are.

The CML researchers have contributed to the atlas in the following ways: Schrama wrote a chapter together with Dr. Roel van Klink of the University of Bern about the effects of grazing on soil fauna. Bodegom contributed a global map of soil microbial biomass and Soudzilovskaia a global map of plant root colonization by mycorrhizal fungi.

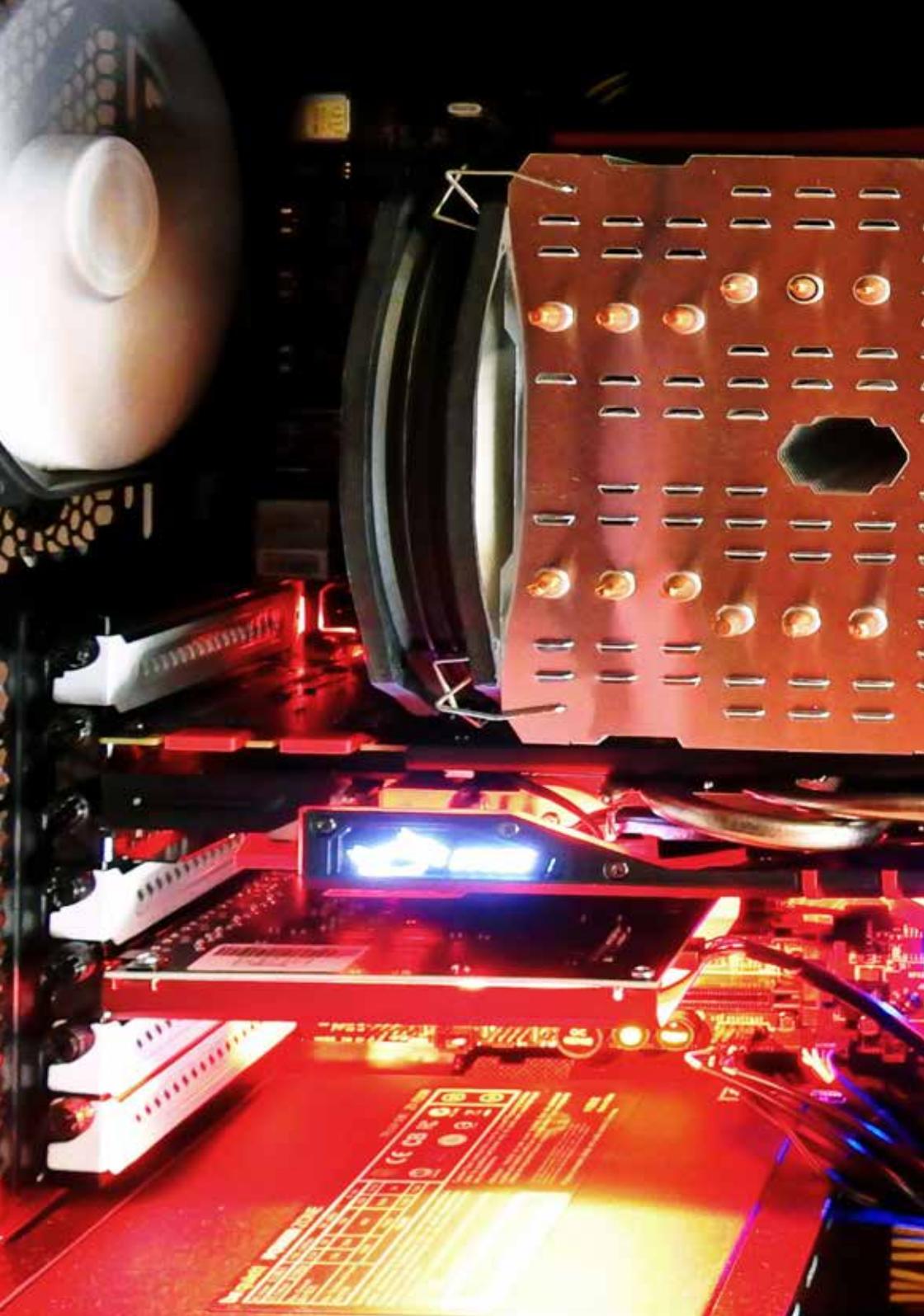
Achieving EU Goals

The Global Soil Biodiversity Atlas raises awareness on the role of soil organisms in sustaining life on our planet, and presents the latest research on soil biodiversity. It is also a major contribution to the EU target of halting the loss of biodiversity and ecosystem services in the EU by 2020, and the goals of the 2030 Agenda for Sustainable Development on sustainable food production and fighting land degradation. Presently, no country has legislation that specifically protects soil biodiversity.

Download the Atlas:
tinyurl.com/soilatlas

“This Atlas contributes to putting together otherwise fragmented knowledge on soil biodiversity. Thanks to the rich scientific evidence, it will become a loud voice helping to preserve soil”.

Tibor Navracsics, European Commissioner for Education, Culture, Youth and Sport.



Bitcoin's surprising Energy Hunger

CML researcher Sebastiaan Deetman models scenarios for bitcoin's energy consumption

The cryptocurrency bitcoin is incredibly energy intensive. To raise awareness on this issue, CML researcher Sebastiaan Deetman published an article on the tech blog Motherboard. He calculated that, if the bitcoin network keeps expanding the way it has done recently, it could lead to a continuous electricity consumption that lies between the output of a small power plant and the total consumption of a small country like Denmark by 2020.

Why is bitcoin so energy intensive? The main reason is its value. At the moment of writing one bitcoin is worth almost a thousand Euros, while on its release in 2009 it was worth seven cents. Every ten minutes volunteers, so-called 'bitcoin miners', try to crack a code in exchange for brand-new bitcoins. The more processing power miners have, the more chance they have of cracking the code. Bitcoin mining today generates a huge amount of heat through its electricity demand, but is still highly profitable because bitcoins are so valuable.

Deetman modelled bitcoin's development. The results show that in an optimistic scenario, the projected increase in electricity consumption of the bitcoin network compared to now is not shocking, from around 350 MW to around 417 MW. If things play out a little less favourably, however, the network may use over 14 Gigawatts of electricity by 2020. As climate change is becoming a more pressing concern every day, bitcoin's huge level of energy use is difficult to justify. Deetman's findings shocked the bitcoin community and started a lively discussion on how to reduce its energy usage.

Industrial Ecology students publish Cloud Footprint Calculator

Not only does bitcoin have a surprising energy use, cloud use does as well. Counter to popular belief, cloud use is not an infinite or a material-free alternative to pen and paper. Deetman supervised a group of Industrial Ecology students who researched the environmental impact of cloud storage.

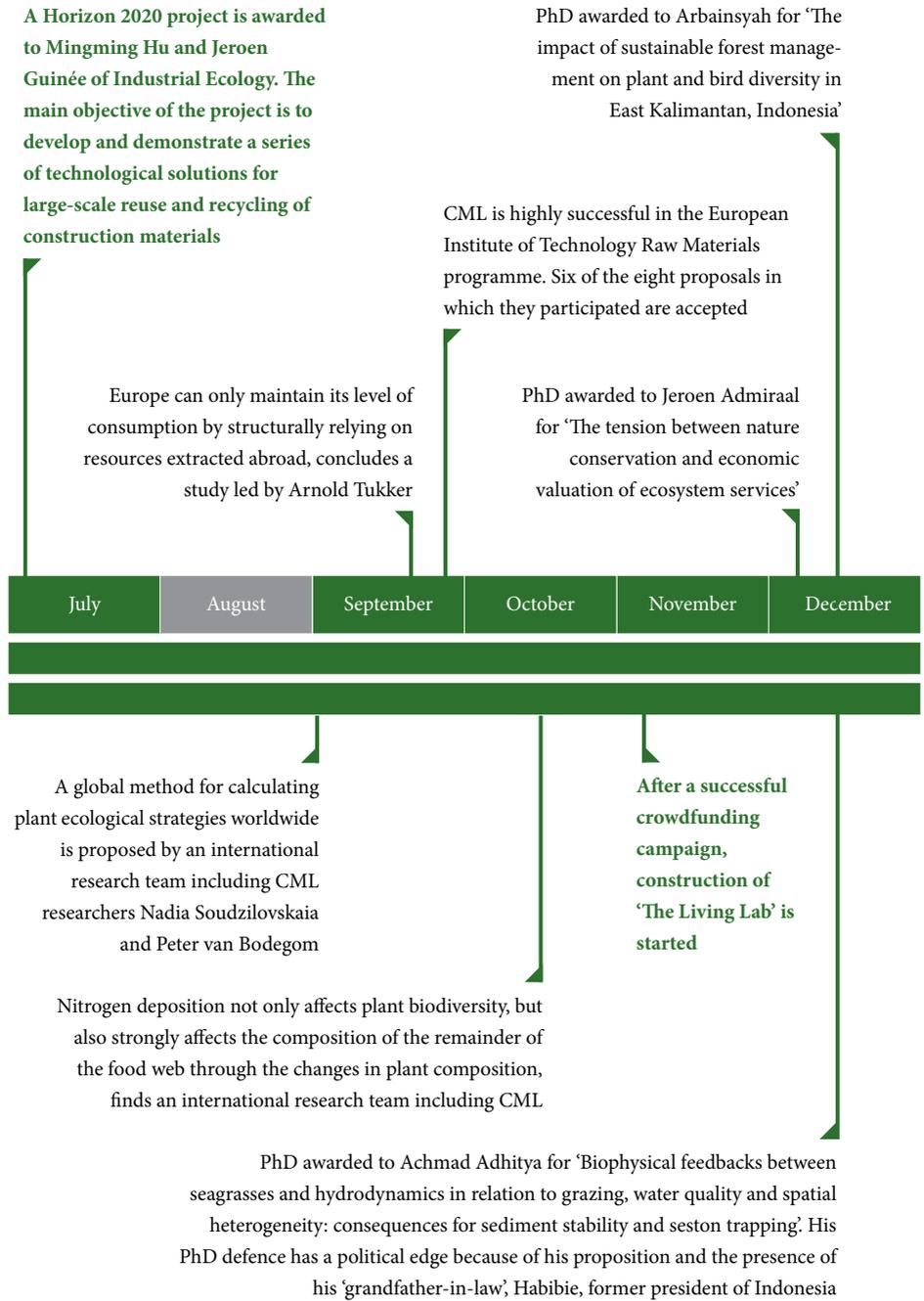
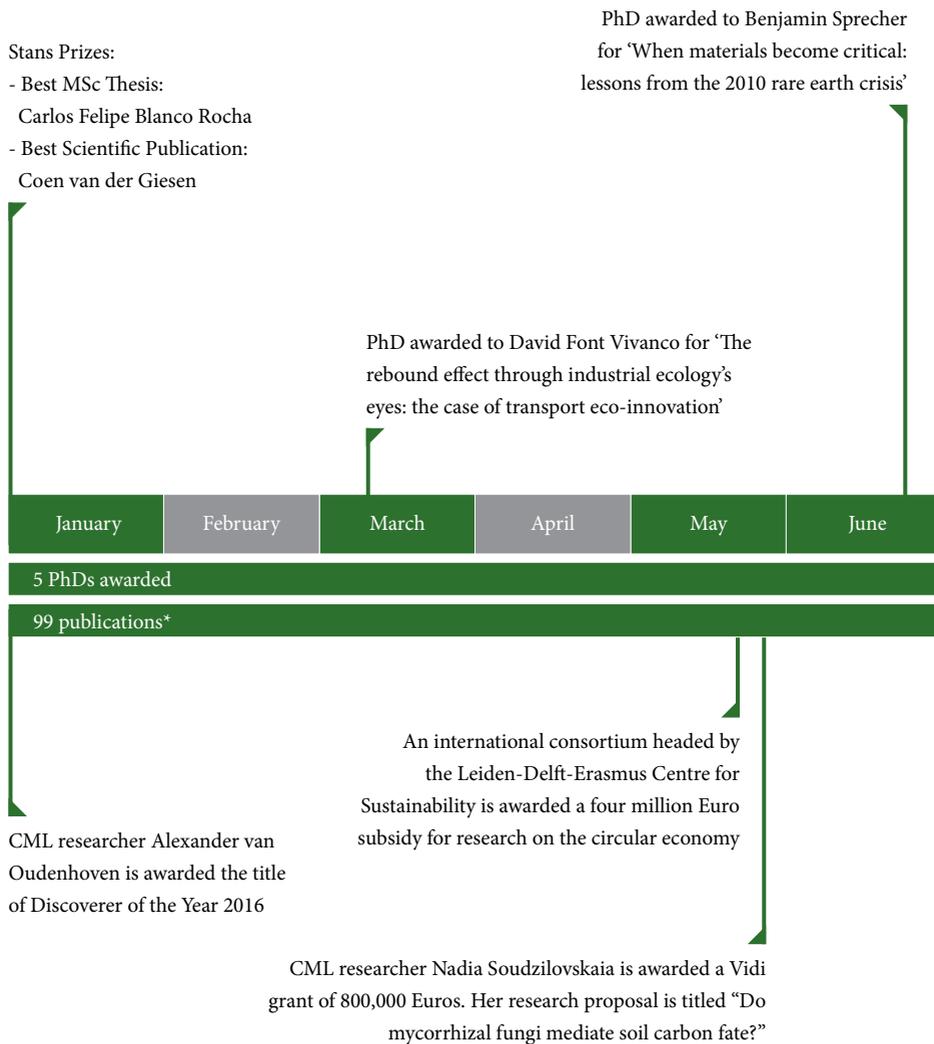
Read Deetman's article:
tinyurl.com/bitcoinelectricity

Calculate your cloud footprint:
www.cloudfootprint.net

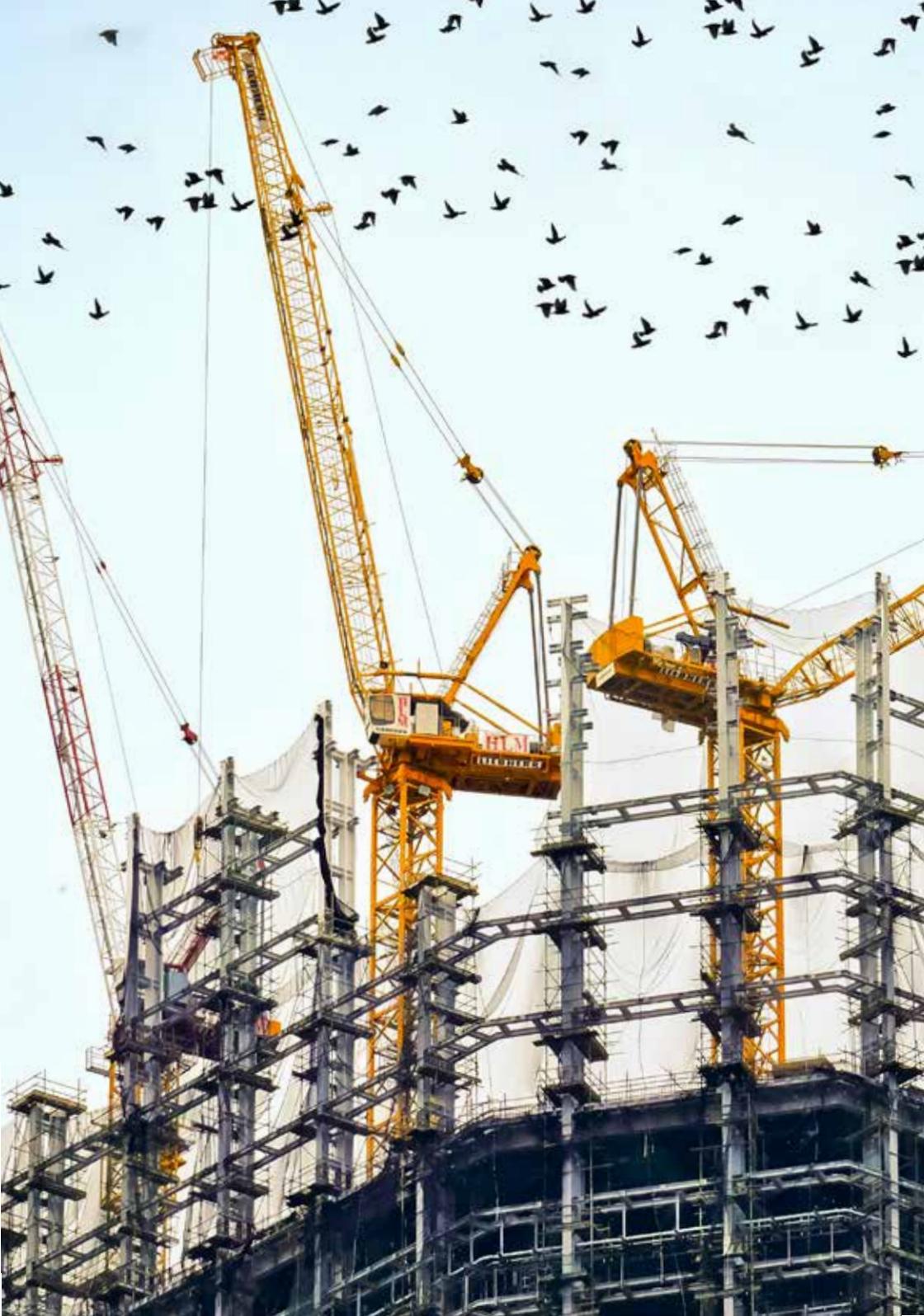
"I wrote this article for Motherboard because I wanted to generate awareness on the huge energy demand of bitcoin"

Sebastiaan Deetman, PhD researcher working on resource efficiency of critical materials

Research 2016



*For a complete list of all publications: www.cml.leiden.edu/publications



Giving a Second Life to Construction Waste

Studying the environmental and economic aspects of reusing construction materials

461 million tons of construction and demolition waste is generated in the European Union (EU28) every year. That is approximately 41,000 times the weight of the Eiffel Tower. Mingming Hu and Jeroen Guinée of Industrial Ecology started a new Horizon 2020 project in October, the third Sustainable Construction Waste Management project of the department.

The main objective of the project is to develop and demonstrate a series of technological solutions for large-scale reuse and recycling of construction materials. Recovered materials are mostly concrete (60-70% of construction waste), but also parts of glass and mineral wool waste. The recycled material will be used as raw material to produce prefabricated concrete and thermal isolation material that can be used to refurbish buildings, aiming at improving their energy performance.

Life cycle assessment (LCA) and life cycle costing (LCC) are used to steer the search for cost-effective and environmentally sound innovations. This offers the opportunity to simultaneously analyse the environmental and economic aspects of product alternatives. Fifteen European partners from academia and industry are involved in the consortium.

Concrete to Concrete Demonstration

On the 10th of June 2016, nearly 200 professionals from all around the world and European Commission Officials joined a Concrete to Concrete demonstration. The project is a continuation of the successful EC FP7 project - C2CA, in which the innovative technology led to the establishment of a joint venture for concrete recycling. Mingming Hu, Jeroen Guinee and René Kleijn from CML contributed to the project by providing integrated environmental and economic assessment on concrete recycling from a life cycle perspective.

Read more about the project:

www.hiserproject.eu

"I'm proud that my work contributes to making concrete recycling a sustainable business!"

Mingming Hu, CML researcher working on regional metabolism, particularly related to construction



Building a Laboratory in Nature

CML team raises €15,000 through crowdfunding to build a 'Living Lab'

We are dependent on water to quench our thirst, for agriculture, swimming and so on. Unfortunately, large quantities of chemical compounds enter our waterbodies every year, mainly due to industry and agriculture. Despite years of research, there remains a knowledge gap on the effects of these chemical compounds in our natural waters. That is why CML started a crowdfunding campaign to raise money to build a laboratory in nature.

In eight weeks' time the money was raised to start building the laboratory. The project was featured in over 15 different news media, such as the Dutch news broadcasting agency NOS, the national newspaper Trouw and the radio shows Een Vandaag and Vroege Vogels. Construction of the laboratory started on the 14th of November. The laboratory is the first of its kind in the Netherlands. The Rijnland District Water Control Board and Naturalis Biodiversity Center are partners in the Living Lab.

The Living Lab consists of 36 experimental ditches that are fed with water and living organisms from an adjoining pond. All the living organisms in these waterways form a single ecosystem and are important in a range of different processes, such as purifying our water. So far too little is known about the impact of chemical compounds on biodiversity in our water and on water quality; this is because research is mainly carried out on separate types of organisms in the controlled environment of a laboratory. The aim of the Living Lab is to determine the effects of chemical compounds on aquatic biodiversity and on water quality in a more natural environment.

Living Lab Research and Education

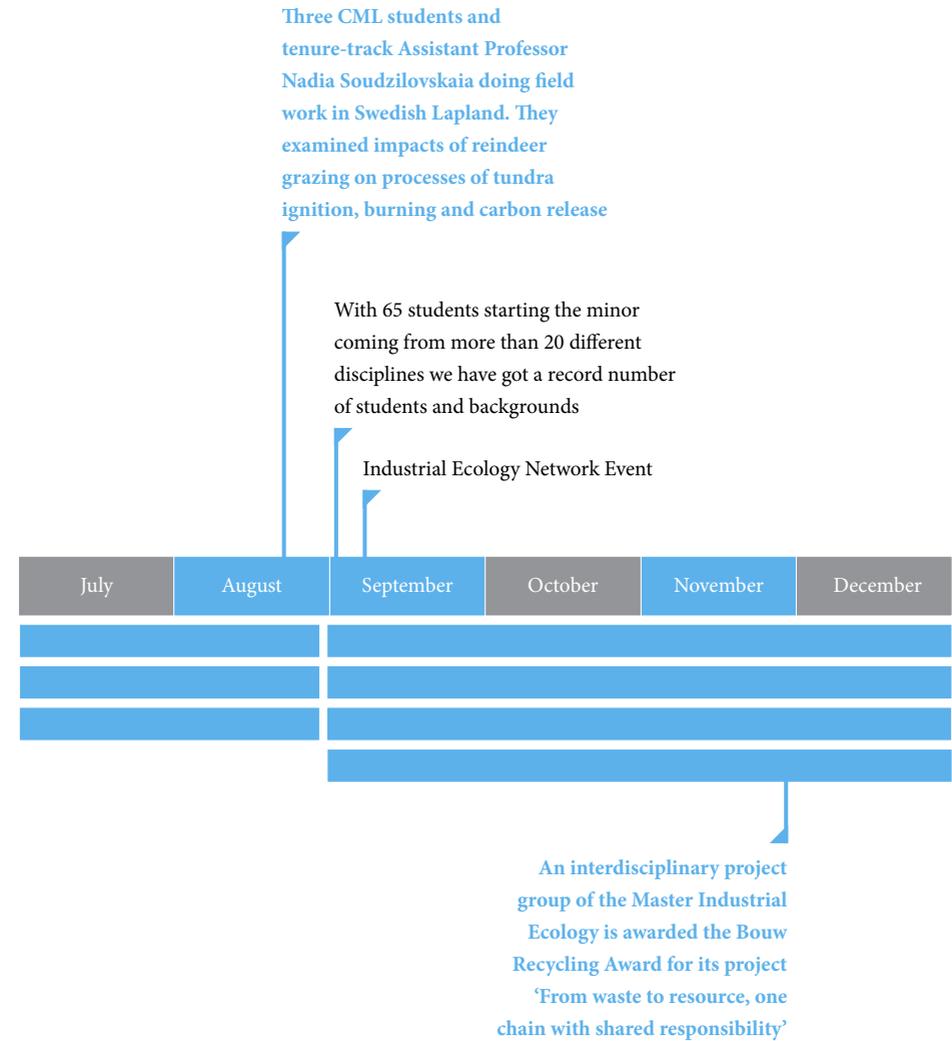
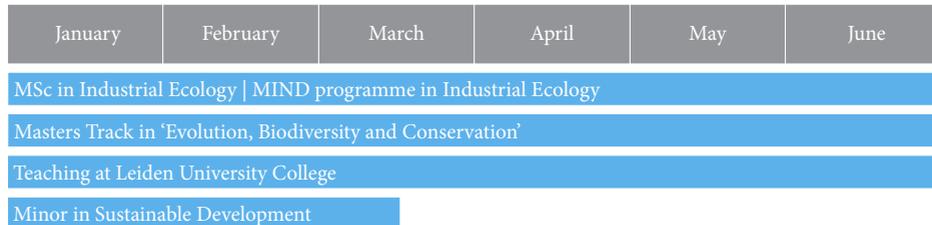
CML will use the Living Lab to study the effects of pesticides on small water organisms and ecosystem processes. Besides research, the laboratory also has an educational aim, which is to disseminate knowledge from the university through social media and a blog. In addition, educational programs are being developed for primary schools, which can visit the laboratory.

Follow the Living Lab (in Dutch):
tinyurl.com/LivingLabCML

"I loved all the enthusiastic reactions of people I had never met before, but who believe your research is necessary."

Henrik Barmantlo, PhD researcher working on quantifying the influence of chemicals in ditch systems

Education 2016





From Waste to Resource

Industrial Ecology students win Dutch recycling award

How can sensor technology contribute to a transition towards a circular economy? Six Industrial Ecology students looked into this question for the course Interdisciplinary project groups. They won the ‘BouwRecycling Award’, an annual Dutch award for the most promising student project contributing to the circular economy.

The students’ research question was: ‘In what ways can a continuous flow of information on the exact composition of household waste facilitate the transition towards a circular economy for materials?’ They envisioned a future sensing system that would know all there is to know about waste materials in Amsterdam, from material composition to batch code. How can such a system contribute to establishing closed loops for materials? To limit their research scope, they decided to focus on plastic packaging in household waste.

Through stakeholder interviews and a literature study the students discovered that having an

elaborate monitoring system alone is not enough to establish a circular economy. Suzanne Dietz, one of the students that worked on the project, explains: “The database we envisioned can support policy makers and companies in many ways in their decision-making, but its impact will only be substantial when knowledge sharing, and acting on this knowledge, becomes a common practice in material and product production chains.”

Interdisciplinary Project Groups

The project was part of the Industrial Ecology ‘Interdisciplinary Project Groups’ course. Problem-oriented education allows second-year students to cooperate across various disciplines and come up with practical solutions. The six students that were involved in the study are Alice van Rixel, Chloé Lejeune, Jason Kiem, Nadiéh Kamp, Suzanne Dietz and Tim van Dijken. Their backgrounds vary from anthropology and communication science to product design and mechanical engineering.

More info about Industrial Ecology Master degree: mastersinleiden.nl/programmes/industrial-ecology

“To establish a circular economy, it is essential that knowledge on reuse and recycling of products and materials reaches producers and designers.”

Suzanne Dietz, Industrial Ecology student



Can Reindeer grazing prevent Tundra Fires?

Three CML students and their professor travel to Sweden to find out

Climate change is increasing the risk of fire in tundra. Tundra fires amplify climate change, damage arctic wildlife, decrease biodiversity and endanger people's livelihoods. Three CML students and tenure-track Assistant Professor Nadia Soudzilovskaia have done field work in Swedish Lapland examining the impacts of reindeer grazing on processes of tundra ignition, burning and carbon release.

Climate change is expected to be strongest in polar areas throughout this century with increased risk of extreme events such as tundra fires, due to higher temperatures and increased risk of drought. In 2007, a severe tundra fire in the Anaktuvuk River region in Alaska demonstrated the realism of these scenarios. This fire damaged 1,000 km² of peatland. This released 2,100,000,000 kg of carbon into the atmosphere, an amount comparable to the carbon being sequestered in one year within the entire Arctic tundra biome.

In addition to their direct effects on carbon emissions, arctic fires seriously damage ecosystems and their biodiversity and endanger people's livelihoods. Considering the large scale and impact of this potential damage, it is critically important to understand the mechanisms of fire development in tundra. A very important factor underpinning tundra vegetation composition is reindeer grazing, known especially to reduce the cover of highly flammable plant species such as lichens and dwarf shrubs.

Field work in Swedish Lapland

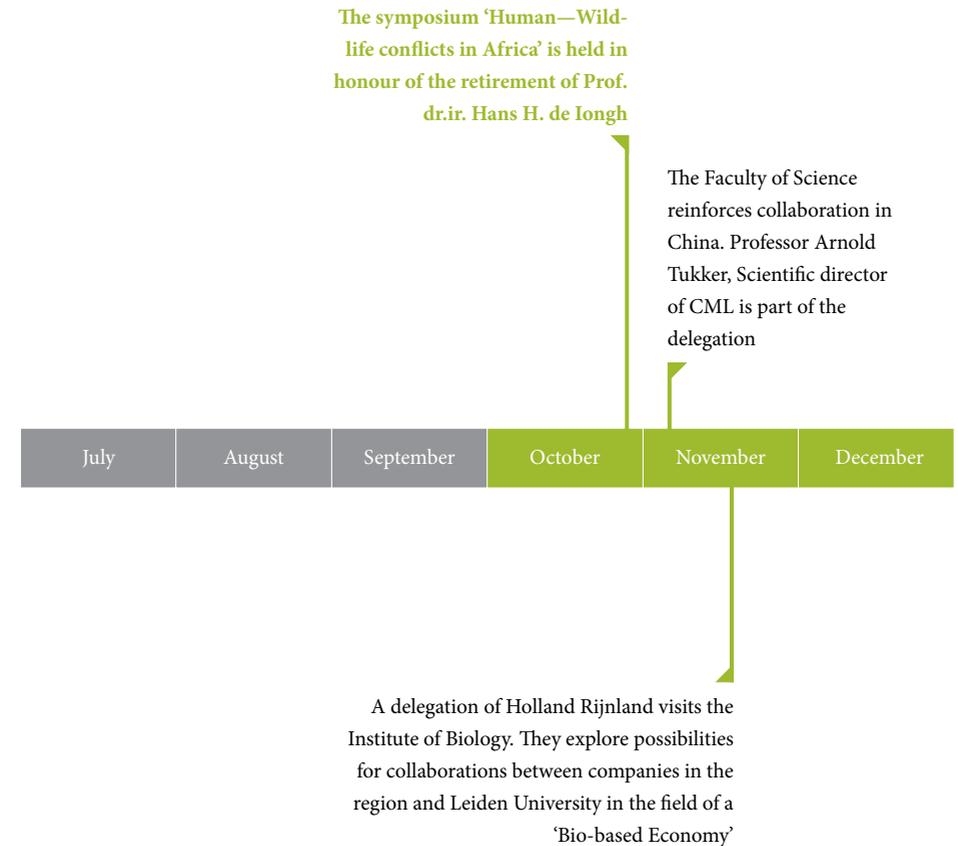
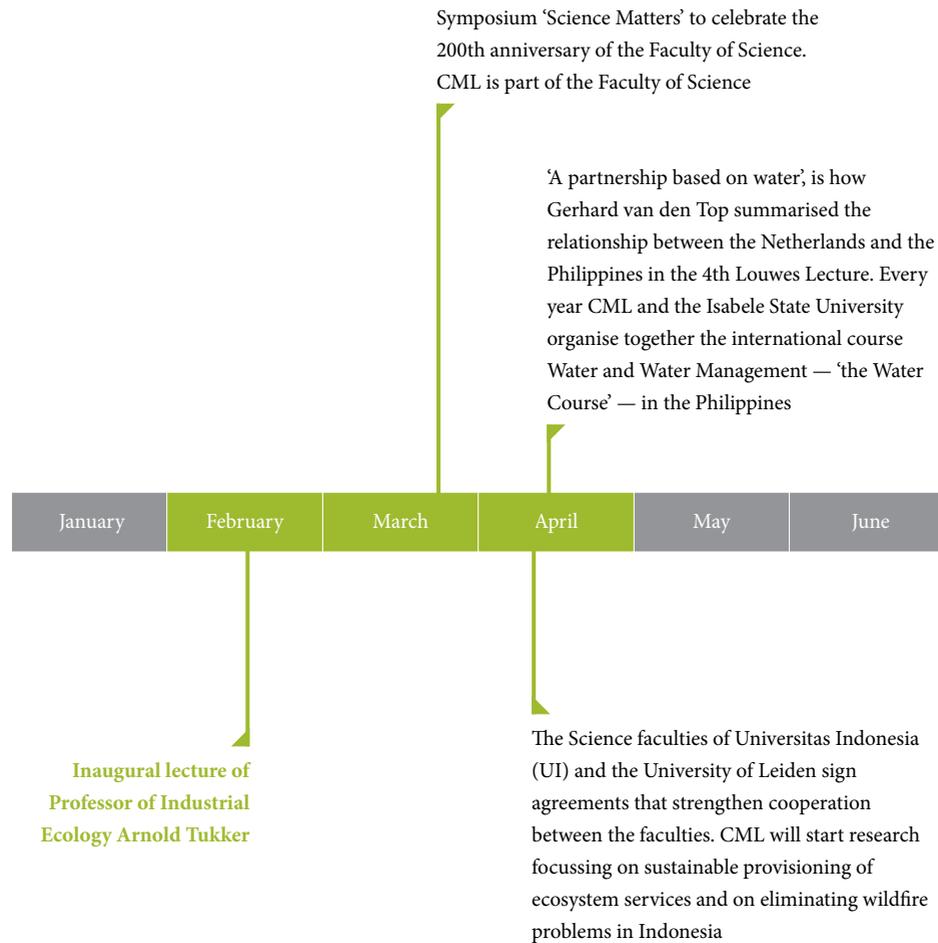
The CML project aimed to test the hypothesis that tundra fire risk may be considerably reduced by the wider introduction of reindeer in the sub-arctic region. It was conducted in the Abisko area of North Sweden by three students of the Conservation Biology department of CML under the supervision of a tenure-track Assistant Professor, laureate of a prestigious Vidi grant, Dr. Nadia Soudzilovskaia.

Read more about the Tundra Fire research project: tinyurl.com/tundrafires

"I truly believe I have never before while studying learned so much. Preparation, fieldwork, experimental setup and execution, analyses and organizing the whole thing on every field trip I discovered practical lessons to be learned"

Sybren Hilgen, Biology student

Organisation 2016





CML Professor Hans de Iongh receives Royal Honour

He is celebrated for his lifelong nature conservation efforts

Professor Hans de Iongh was named 'Officier in de Orde van Oranje Nassau' by the Mayor of Leiden on Thursday 27 October 2016. During more than 25 years at CML De Iongh has been involved in numerous research and conservation projects related to human-wildlife conflicts in Africa and Asia. He received the Royal Honour during a symposium in tribute of his retirement titled 'Human - Wildlife Conflicts in Africa'.

Though working at an academic institute, De Iongh always had a keen interest in the implication of research results for nature conservation. Parallel to his research work is a long history of more applied nature conservation activities. Hans de Iongh has been active in the protection of the tropics since 1990. He was programme coordinator of different university co-operations in Asia and Africa. During

his time as coordinator he was involved in research on the protection of large mammals, conflicts between people and wild animals, sustainable forest management and the use of natural resources.

His biggest interest was large predators (mainly lions) and the conflicts between humans and these predators. With his active role in the International Union for the Conservation of Nature (IUCN) he contributed substantially to the protection of these intriguing animals.

Putting Collars on Lions

One of the projects Professor de Iongh worked on is the collaring of lions in Nairobi National Park. The satellite collars send an SMS warning to scientists if lions come within 500 meters of livestock corrals. A rapid response team of local rangers can then intervene by going to the area to assist the Maasai livestock owners. The project has resulted in a significantly lower mortality rate among lions.

Explore the work of Professor Hans de Iongh: tinyurl.com/HansdeIongh

"Without the collaring programme, the retaliatory killing of livestock-raiding lions by Maasai would have continued. And with a population of only 35 lions in Nairobi National Park, this could have led to the extinction of the entire population."

Hans de Iongh, Associate Professor of Conservation Biology



The Circular Economy as Recipe for Sustainability

Inaugural lecture by Industrial Ecology
Professor Arnold Tukker

A circular economy in which all resources are reused is a prerequisite for a sustainable world. As EU president, the Netherlands can give a firm impetus to this economic shift. This was the message of Leiden Professor of Industrial Ecology, Arnold Tukker, in his inaugural lecture on 26 February. There can be no doubt, Tukker explains, that a collective move to a circular economy is essential for a sustainable world.

Tukker, who is also Scientific Director of CML and chair of the board of CfS (Leiden-Delft-Erasmus Centre for Sustainability), talks about the huge challenges our world is facing. The world population will continue to grow for the foreseeable future and almost all countries want their economy and prosperity to do the same. 'That makes it extremely difficult to reduce carbon emissions to the levels agreed during the climate summit in Paris,' Tukker warns.

A circular system means that far fewer primary resources are needed for society to be able to function because the materials we use are recycled as much as possible. That is a much bigger picture than occasionally opting for recycled toilet paper. 'To put it simply, a circular economy based on 80 per cent re-use can be around five times the size of its linear counterpart, using the same amount of primary resources,' Tukker explains.

Global Material Flows

Over the coming period, Tukker and the research teams from the Centre for Sustainability and CML will be charting the global flows of materials. The aim is to set up as many comprehensive databases as possible that can be combined to make predictions, for example about the transport and use of solar cells or critical issues that jeopardise efficiency.

Read Arnold Tukker's inaugural lecture (in Dutch):
tinyurl.com/inaugurallecture

Explore the work of Professor Arnold Tukker:
tinyurl.com/ArnoldTukker

'If we build circularity into our systems now, particularly in countries with emerging economies, we will create a sustainable basis for future recycling.'

Arnold Tukker, CML's director and Professor of Industrial Ecology



See you next year?

We trust this annual report has given you an idea of our institute's activities and successes in 2016. For additional information, please visit our website: cml.leiden.edu or contact us on +31 (0)71 5277461 or by email at secretariaat@cml.leidenuniv.nl. We look forward to hearing from you.

We are proud of what we achieved last year and are excited about what the future will bring!

CML staff, researchers and students

Colophon

Compiled by Merel Segers
Sustainability Analysis & Communication.

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Our thanks go to all the CML staff, researchers and students who contributed to this report:

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