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The town as a concentrated source of reclaimable water and materials. Opportunities for an engineered conservation strategy

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ABSTRACT

A fierce theoretical debate is ongoing about the human species' existence itself being sustainable for Earth and for living world. In the meanwhile cities, which are considered to concentrate the mankind's ecological footprints, are steadily growing and gathering huge populations worldwide. This paper assumes that margins do exist to relieve man's burden on Nature to some extent, and that – regardless of our general concept of the matter – these margins should be exploited. The focus of this note is on beneficial use of waste water and waste to spare new resources and to create filter areas close to towns or belts around them. A brief reference is made to some official declarations and indices published on biodiversity in anthropic environments, such as the one from UNEP.

KEYWORDS Anthropic environments; Biodiversity; City planning; Resources; Urban Ecology.

INTRODUCTION

Exactly forty years have elapsed since the issue of the ever most popular synthesis of criticism to unrestrained use of Earth's resources (Meadows D. et al., 1974). Pressure and unbalancing actions on natural cycles have not relented yet; and much of them are debited to cities, the exemplar man-made environment. It is documented that actually cities are steadily growing worldwide (WHO, 2014). The urban population in 2014 accounted for 54% of the total global population, increased from 34% in 1960; with all the related needs for areas, for every kind of supplies and for waste management.

At least relieving measures are due and urgent, and some of them were envisaged as early as 1969 by E. P. Odum (Odum, 1969; Odum, 1971).

It is still a matter of debate whether a urban ecology can exist, and – if it can – whether it obeys to the general laws of ecology or to any special rules of its own. This issue is only briefly dealt with in this paper. Anyway, in a pragmatic approach at least some indicators and indices ought to be agreed on, in order to give a transparent measure of the environmental benefits achieved through given mitigation actions possibly undertaken.

CITIES, MANKIND AND RESOURCES

Historically, villages, towns and cities have been made by men for themselves

- to develop broader and more free exchanges of goods, manpower and skills
- to find customers for technological products
- to benefit of more qualified services; of medical care; of higher education;
- to build up wealth
- to feel safer, etc.

Cities obviously use land that often formerly belonged to some other species. The ratio

(covered area / people living in)

can actually be lower in towns made of tall buildings than in sprawled ones; indeed, this was the concept of Le Corbusier and other architecture Masters. Denser towns, however, have less possibilities of growing orchards, vegetable gardens, firewood lands, fisheries, etc.; so they need to fetch resources from far, unless flat roofs are used to this purpose. The two arrangements can obviously coexist in different quarters of the same town (Figure 1).

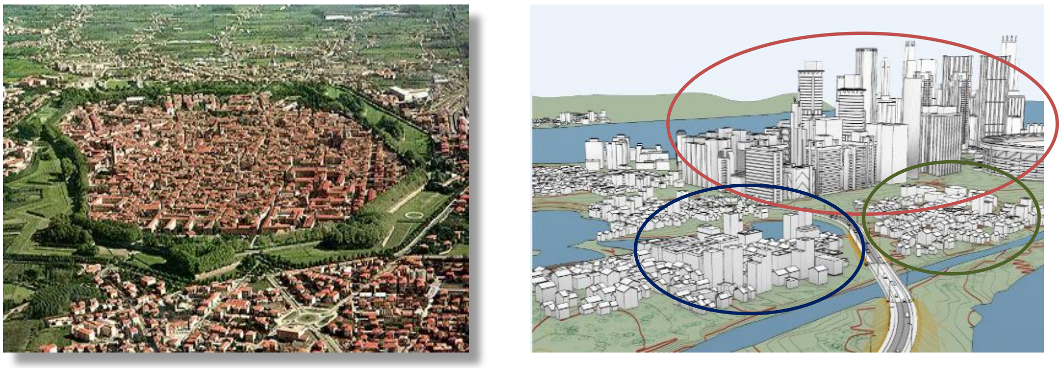

Figure 1. A historical walled town (left) with its circular concentric gradient of buildings, green belt and surrounding countryside; a modern town (right) with regulated quarters planned for different functions.

Cities necessarily draw most of the resources they need from far; freshwater first. Figure 2 shows the orders of magnitude of the materials and energy exchanges of a middle capital town peopled by about 600 000, *per annum*.

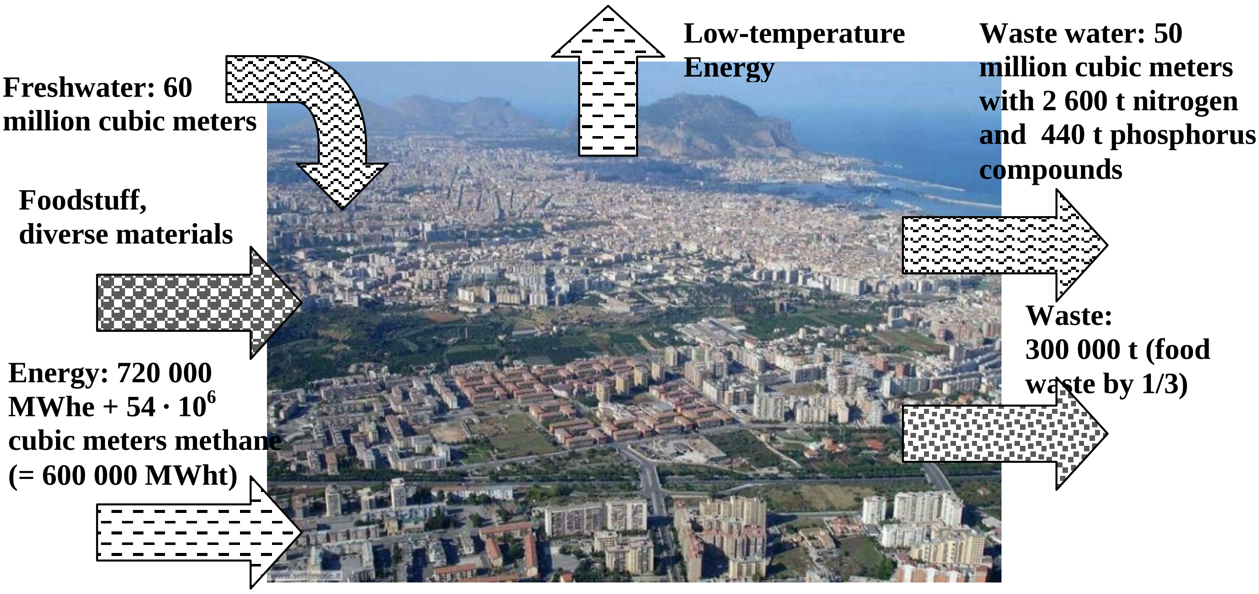

Figure 2. The city of Palermo as a case-study: some major flows of materials and energy (civil uses only).

It is hardly possible that the used resources can be given back to their sources, or original places or states. Restitution is usually not feasible because, for instance: water is drawn from higher elevation sources and discharged into lower water bodies; foodstuffs are partly simply eaten, partly discarded; energy is downgraded in its use.

Figure 3. Left: The reservoir *Piana degli Albanesi* (610 m above sea level) is a multi-purpose water source for uses in the coastal plain of Palermo. Right: Example of heat losses in old-fashioned, low-tech town heating systems.

DOES URBAN CIVILIZATION NECESSARILY THREATEN BIO-DIVERSITY? COULD IT RATHER BE HELPFUL IN SOME WAY?

It is likely that diversity decreases where and when

- a portion of a vital primary resource – e.g., high quality water - is diverted;
- great amounts of secondary resources such as wastewater and organic matter – although treated – are discharged into limited seawater volumes;
- nuisances like warming; lighting; noise; men's stamping on, or walking through; traffic; navigation etc. advantage opportunistic species like rats, wasps, seagulls, ravens, magpies and drive away the most sensitive ones.

Some common blames to towns, however, appear still ill-founded. As for now it looks more an article of faith than a demonstrated and explained fact, that at sea the outfall of a constant – discharge sewer after proper treatment; or a storm sewer; would generate more harmful gradients of salinity and turbidity, than a river with its natural alternation of dry-weather flows and flood flows (Figure 4).

Figure 4. Plume of suspended solids at the mouth of a river (left) and flowing out from an on-shore outfall (right).

Some positive effects that a well intentioned town can develop towards wildlife are:

- Storing fresh water and – where possible - treated wastewater, so smoothening floods / droughts
- Mitigating climate through managed green areas, leading to less ecological stress
- Providing shelter to timid species
- Pouring organic matter in oligo-trophic biotopes, resulting in an enhanced food pyramid.

The debate on urban civilization against bio-diversity urges us to define - in a really scientific and consistent way - what the civilization could be like; how much of resources it strictly ought to require / use; and how bio-diversity is to be quantified (what addresses us to suitable Indicators and Indices).

The concept of integrating town and nature through *filter ecosystems* was enunciated and gradually better defined in the Seventies and Eighties by E. P. Odum (1969 and 1981; cit.) and by H. T. Odum (Odum, 1983). Z. Naveh coined in 1982, and used since then (Naveh, 2000) the term *techno-ecosystem* to represent systems where technology and ecology are associated. These are the realm of ecological engineering.

Figure 5 suggests a possible application of these concepts.

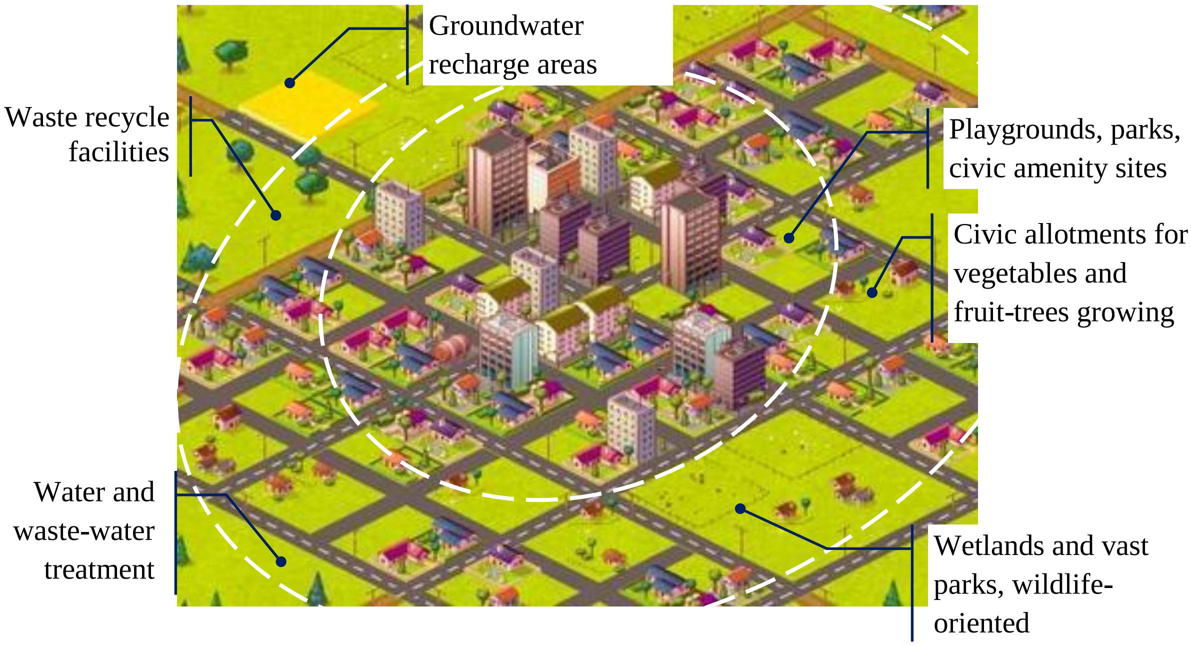

Figure 5. A urban area featuring an ecological filter belt and an outer filter area.

THE ACTUAL ORDERS OF MAGNITUDE OF RESURCE RECOVERIES

A medium – large town can provide, to itself and to its surroundings, treated wastewater enough to turn a squalid channel into a 2 m^3/s steady flow watercourse; or 100 hectares brownfield into a wetland.

This benefit is not entirely free, since 1 m^3 of biologically treated wastewater contains the *embedded energy* of about 0.4 kWh; but most of this amount should have been expended anyway, just to meet the quality requirements at the discharge point.

Figure 6. A possible ecological succession for derelict land turned into wetland.

The same town can also provide to itself and to its surroundings **40 000 t compost**: enough for **2 ÷ 4 000 hectares soil** being annually amended. What to do with such engineered ecosystems is obviously to the environmental biologists' expertise.

Figure 7. Left to right, clockwise: windrow composting; compost handling; plant germination.

Two vast chapter apart are those of green roofs and of underwater barriers laid for aquatic fauna breeding and growing.

Green roofs can control urban climate; reduce and smoothen water runoff; give shelter and ecological corridors to animals and spontaneous plants, and more; provided that mechanical energy (usually drawn from the electrical grid, actually) is supplied to lift stored rainwater from the underground reservoirs.

Underwater barriers have been experienced, investigated and discussed too much for requiring more treatment here.

RESHAPING TOWNS AND SETTING THEM TO WORK FOR NATURE. INDICATORS AND INDICES OF ACHIEVEMENTS

Since urbanization is fundamentally changing the nature of our planet, preserving biodiversity in this new urban world requires going well beyond the traditional conservation approaches of protecting and restoring what we think of as “natural ecosystems,” and trying to infuse or mimic such elements in the design of urban spaces. After two official sources: CBD – the UN’s Convention on Biological Diversity; and the Working Group CBO - Cities and Biodiversity Outlook; “Cities have a large potential to generate innovation and governance tools and therefore can —and must— take the lead in sustainable development. Many of the opportunities can be found in nature - based solutions, using ecosystems in novel ways to address some of the most pressing challenges, such as climate change, water and food security, and poverty relieving. The way forward involves reimagining cities as places of biodiversity, and as sources for valuable services, rather than only sinks that mark ecological footprints.” After CBO (based at Stockholm University, SE) “… rich biodiversity can exist in cities; but it cannot be taken for granted that it will be the same as before urbanization. Habitat conversion often leads to the loss of “sensitive” species dependent on larger, more natural clusters of habitat for survival.

Cities already represent in themselves a new class of ecosystems shaped by the dynamic interactions between ecological and social systems”.

It is still a matter of debate whether a urban ecology can exist, and – if it can – whether it obeys to the general laws of ecology or to any special rules of its own (see further on in this paper). Anyway, in a pragmatic approach at least some indicators and indices ought to be agreed, in order to give a transparent measure of the environmental benefits achieved trough certain actions.

Among the Indicators of Diversity we will cite here the Singapore Index (SI), 2008. This is a self-assessment tool for cities to benchmark and monitor the progress of their biodiversity conservation efforts compared with their own individual baselines.

It comprises:

a) the “Profile of the City”, which provides comprehensive background information on the city;

b) 23 indicators based on the guidelines and methodology provided.

The scoring of the Index is quantitative in nature; a maximum score of 4 has been allocated to each indicator, and with the current count of 23 indicators, the total possible score of the Index is 92 points.

Table 1. The Singapore Index (SI): example of the working tables: a local ecosystems inventory.

CBI	COMPONENTS	INDICATORS	VARIABLES	SCORE	MAXIMUM
	1. Native Biodiversity in the City	(IND.2) Diversity of ecosystems **RATIONALE FOR SELECTION OF INDICATOR** The number of natural ecosystems found in a city gives an indication of the diverse range of niches for native flora and fauna. Since different ecosystems are found in different geographical regions, any scientifically acceptable terrestrial and marine ecosystems, including forests (tropical, subtropical, monsoon, temperate, lowland, montane, primary, secondary, etc.), mangroves, freshwater swamps, peat swamps, natural grasslands, rivers, streams, lakes, rocky shores, beach, mud-flats, sand dunes, sea grass beds, corals, etc., can be computed in the calculation of this index.	(IND.2) Diversity of ecosystems **HOW TO CALCULATE INDICATOR** Number of natural ecosystems found in the city **WHERE TO GET DATA FOR CALCULATIONS** Possible sources of data on natural areas include government agencies in charge of biodiversity, city municipalities, urban planning agencies, biodiversity centres, nature groups, universities, publications, etc.	(IND.2) Diversity of ecosystems **BASIS OF SCORING** A) Based on the estimation that realistically, any city can accommodate to about 10 natural ecosystems, within its boundaries, the scoring would be 0 point - 0 natural ecosystem 1 point - 1-3 ecosystems 2 points - 4-6 ecosystems 3 points - 7-9 ecosystems 4 points - 10 and more ecosystems B) Baseline of 100 C) Traffic line system of increase, neutral and decrease	(IND.2) Diversity of ecosystems **MAXIMUM SCORE** 4 (IND.2)

The year in which a given city first undertakes this scoring program will be taken as its baseline year. The future applications of the Index will be measured against the baseline to chart its progress in conserving biodiversity.

For 7 of the indicators, a statistical treatment will be applied to sample data sets coming from several cities, to ensure the scoring ranges established are unbiased and fair to a broad spectrum of cities of different characteristics, over a wide geographical range.

URBAN ECOLOGY; GOVERNING BIODIVERSITY IN CITIES: A NOBLE COMMITMENT OR A PURE DREAM?

We have now to look at the frame within which the actions for a sustainable town are developed, in order to judge about the theoretical soundness of them and to forecast how far the pragmatic approach outlined above can arrive.

Among the optimistic sources we are quoting here a statement from CBO: “There is a need for redefining the role of cities so that they increasingly provide stewardship of marine, terrestrial and freshwater ecosystems elsewhere. Developing the concept of nature based - solutions entails exploring a deeper dimension of how attributes of ecosystems - such as diversity, modularity and redundancy - may be interpreted, applied and used”.

Another affirmative statement comes from Jari Niemelä (1999): “The question arises whether a distinct theory of urban ecology is needed for understanding ecological patterns and processes in the urban setting. The answer is no; however, due to the intense human presence, approaches that include the human aspect are useful in studying urban systems”.

Collins *et al.* (2000) instead raise serious doubts and develop a close criticism of these perspectives. For these Authors, in studying urban systems the intense human presence certainly obliges to approaches that include the human aspect; still, even such tentative integrated approaches could reveal themselves a dead way.

Quoting the Collins’ words: “From the perspective of a field ecologist examining a natural ecosystem, people are an exogenous, perturbing force. Human beings - and especially their cities, seemingly so "artificial" - fail to fit neatly into ecological theory.

People mobilize some nutrients and deplete others, produce pollutants, drive species extinct, promote the survival of others, change the composition of the atmosphere and alter landscapes. In cities people create habitats that never before existed, divert water, increase temperatures and, by intent or by accident, manipulate the communities of other species found within city boundaries and beyond. (...)".

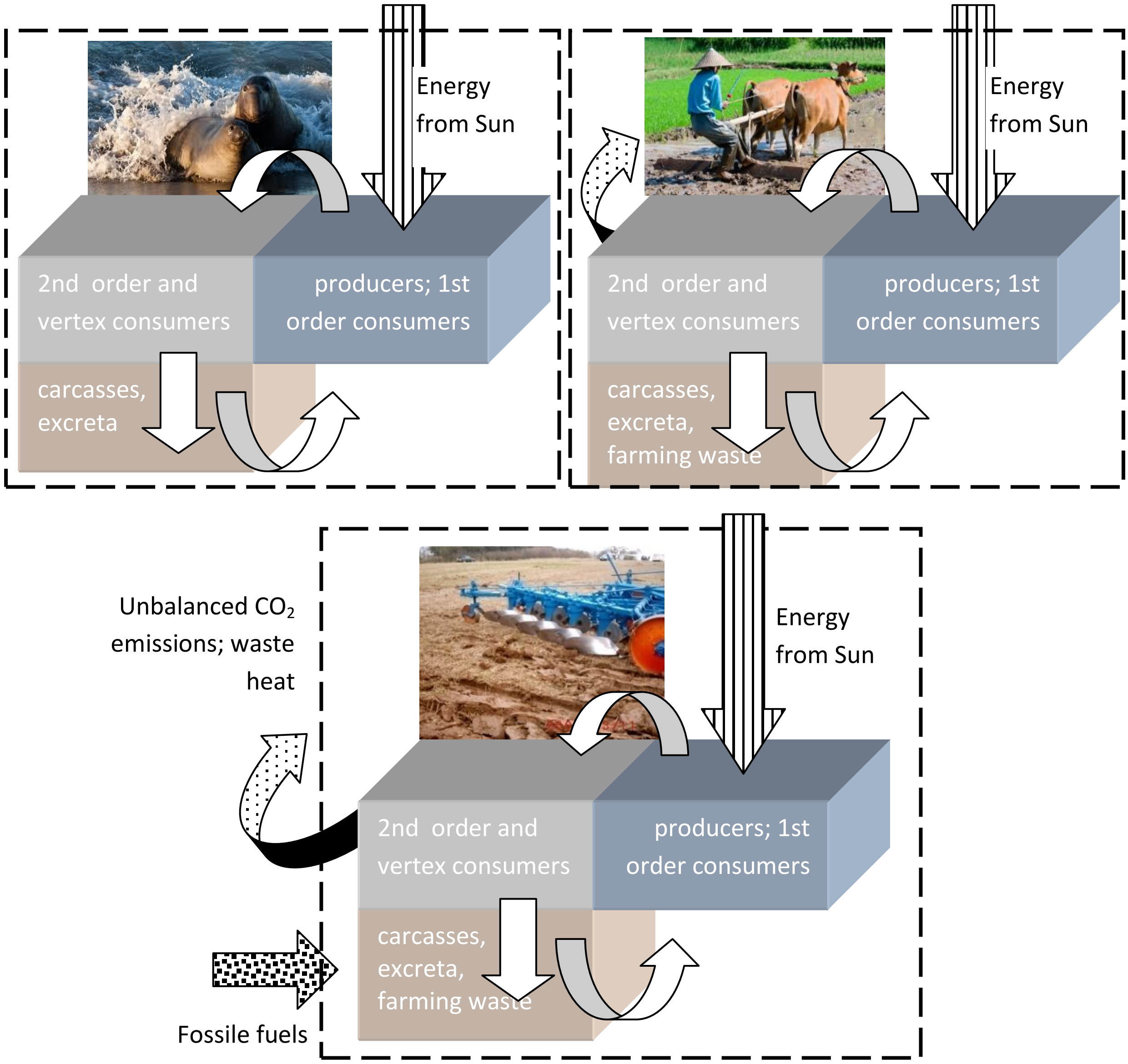

Figure 8. Three types of heterotrophic system (the one upper left in every picture) and their relationships with the surroundings. Tapping of fossil fuels makes the main difference between the three.

After Collins and coworkers, “We lack a method of modelling ecosystems that effectively incorporates human activity and behaviour. And the processes and dynamics within cities largely elude an understanding based on traditional ecological theories. For most [natural] ecosystems the overall calculation is fairly well balanced between inputs and outputs. Urban energy budgets, dominated as they are by deliberate human energy imports and by losses via fossil-fuel burning, do not resemble the energy budgets of any other ecosystem on earth”.

Figure 8 is an attempt to depict this concept.

CONCLUSIONS

Much of the blame put on town ought actually to be put on the human way of life.

We believe that man – as a second-level or vertex consumer – is by no means the only species on Earth whose life is heterotrophic, or that lives in crowded communities.

It is true that his weaknesses (like the need for shelter and warmth and the inability to nourish himself of raw food) and his strengths (such as his unique ability to handle fire, and to make, build up and transfer knowledge, etc.) are peculiar. All this increases the singularities of mankind, but in our opinion does not entail any definition of supposed peculiar human ecological niches.

The only fundamental difference that we see stays in that, that men are not innocent in their behaviour, and ecological feedbacks to their actions are usually overbalanced by their obstinacy. Mankind usually neglects or denies the Nature’s response to its actions, and – if compelled - is more willing to force than to ease. The renounce to such unjustified self-exemption; and a consistent commitment in respecting and saving the other species' lives and spaces; even in towns, at least as a mitigation measure; is the tribute that mankind still owes to Nature.

The Author's speech was dedicated to the luminous memory of Giovanni Falcone and Francesca Morvillo Falcone, and of the men of their escort. Fallen at Capaci – Palermo, May the 23rd, 1992.

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