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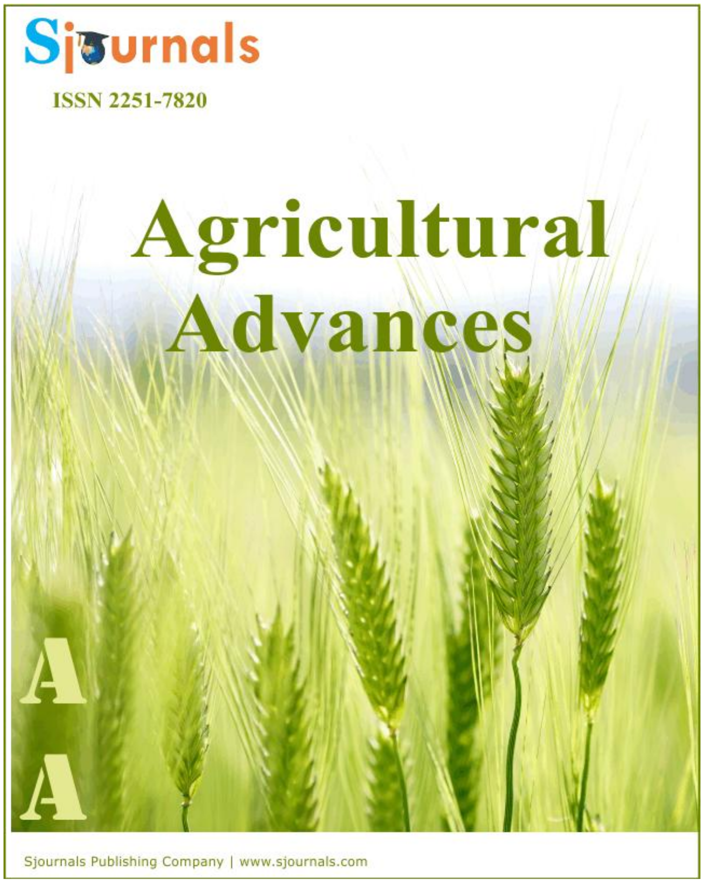

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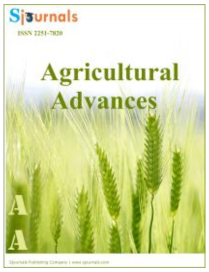

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Review article

Biodiversity, the green ecology, economics and ecosystem engineering

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ABSTRACT

The increased exploitation of renewable energy sources is central to any move towards sustainable development. However, casting renewable energy thus carries with it an inherent commitment to other basic tenets of sustainability, openness, democraticisations, etc. Due to increasing fossil fuel prices, the research in renewable energy technologies (RETs) utilisation has picked up a considerable momentum in the world. The present day energy arises has therefore resulted in the search for alternative energy resources in order to cope with the drastically changing energy picture of the world. The environmental sustainability of the current global energy systems is under serious question. A major transition away from fossil fuels to one based on energy efficiency and renewable energy is required. Alternatively energy sources can potentially help fulfill the acute energy demand and sustain economic growth in many regions of the world. The mitigation strategy of the country should be based primarily ongoing governmental programmes, which have originally been launched for other purposes, but may contribute to a relevant reduction of greenhouse gas emissions (energy-saving and afforestation programmes). Throughout the study several issues relating to renewable energies, environment and sustainable development are examined from both current and future perspectives. The exploitation of the energetic potential (solar and wind) for the production of electricity proves to be an adequate solution in isolated regions where the extension of the grid network would be a financial constraint.

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1. Introduction

The provision of good indoor environmental quality while achieving energy and cost efficient operation of the heating, ventilating and air-conditioning (HVAC) plants in buildings represents a multi variant problem. The comfort of building occupants is dependent on many environmental parameters including air speed, temperature, relative humidity and quality in addition to lighting and noise. The overall objective is to provide a high level of building performance (BP), which can be defined as indoor environmental quality (IEQ), energy efficiency (EE) and cost efficiency (CE).

- Indoor environmental quality is the perceived condition of comfort that building occupants experience due to the physical and psychological conditions to which they are exposed by their surroundings. The main physical parameters affecting IEQ are air speed, temperature, relative humidity and quality.
- Energy efficiency is related to the provision of the desired environmental conditions while consuming the minimal quantity of energy.
- Cost efficiency is the financial expenditure on energy relative to the level of environmental comfort and productivity that the building occupants attained. The overall cost efficiency can be improved by improving the indoor environmental quality and the energy efficiency of a building.

The move towards a low-carbon world, driven partly by climate science and partly by the business opportunities it offers, will need the promotion of environmentally friendly alternatives, if an acceptable stabilisation level of atmospheric carbon dioxide is to be achieved. This communication presents a comprehensive review of energy sources, and the development of sustainable technologies to explore these energy sources. It also includes potential renewable energy technologies, efficient energy systems, energy savings techniques and other mitigation measures necessary to reduce climate changes. The study concludes with the technical status of the ground source heat pumps (GSHP) technologies. The purpose of this study, however, is to examine the means of reduction of energy consumption in buildings, identify GSHPs as an environmental friendly technology able to provide efficient utilisation of energy in the buildings sector.

2. Energy and ecosystems

The energy conservation scenarios include rational use of energy policies in all economy sectors and use of combined heat and power systems, which are able to add to energy savings from the autonomous power plants. Electricity from renewable energy sources is by definition the environmental green product. Hence, a renewable energy certificate system is an essential basis for all policy systems, independent of the renewable energy support scheme. It is, therefore, important that all parties involved support the renewable energy certificate system in place. The potential of the most important forms of renewable energy, such as solar, wind, biomass, and geothermal energies, is shown in Tables 1 and 2. Existing renewable energy technologies could play a significant mitigating role, but the economic and political climate will have to change first. Climate change is real. It is happening now, and greenhouse gases produced by human activities are significantly contributing to it. The predicted global temperature increase of between 1.5 and 4.5 degrees C could lead to potentially catastrophic environmental impacts. These include sea level rise, increased frequency of extreme weather events, floods, droughts, disease migration from various places and possible stalling of the Gulf Stream. This has led scientists to argue that climate change issues are not ones that politicians can afford to ignore, and policy makers tend to agree. However, reaching international agreements on climate change policies is no trivial task.

Ideally, it would promote the integration of different renewable energies and rural development, as well as contributing to the reduction of greenhouse gas emission as shown in Table 3. The concept of an integrated renewable energy farm (IREF) is a farming system model with optional energetic autonomy, which includes food production and if possible, energy exports. Energy production and consumption at the IREF have to be environmentally friendly, sustainable and eventually based mainly on renewable energy sources. The overall objective is that the IREF concept be successfully introduced into agricultural production systems, which have to be completely sustainable, taking into account the following influential factors:

- Impact, influence and needs of climate, soil and crops.
- Ratio of required food/bio-fuel production.
- Input/output requirement for cultivation, energy balance and output/input ratio.
- Equipment choices (wind, solar, biomass generation and conversion technology).

Table 1
Sources of renewable energies.

Source	Form
Solar energy	Solar thermal, and solar PV
Biomass energy	Woody fuels, and non woody fuels
Wind energy	Mechanical types, and electrical types
Mini and micro hydro	A mass water fall, and current flow of water
Geothermal	Hot water

Table 2
Potential, productive, end-uses of various energy sources and technologies.

Energy source / technology	Productive end-uses and commercial activities
Solar	Lighting, water pumping, radio, TV, battery charging, refrigerators, cookers, dryers, cold stores for vegetables and fruits, water desalination, heaters, baking, etc.
Wind	Pumping water, grinding and provision of power for small industries
Hydro	Lighting, battery charging, food processing, irrigation, heating, cooling, cooking, etc.
Biomass	Sugar processing, food processing, water pumping, domestic use, power machinery, weaving, harvesting, sowing, etc.
Kerosene	Lighting, ignition fires, cooking, etc.
Dry cell batteries	Lighting, small appliances
Diesel	Water pumping, irrigation, lighting, food processing, electricity generation, battery charging, etc.
Animal and human power	Transport, land preparation for farming, food preparation (threshing)

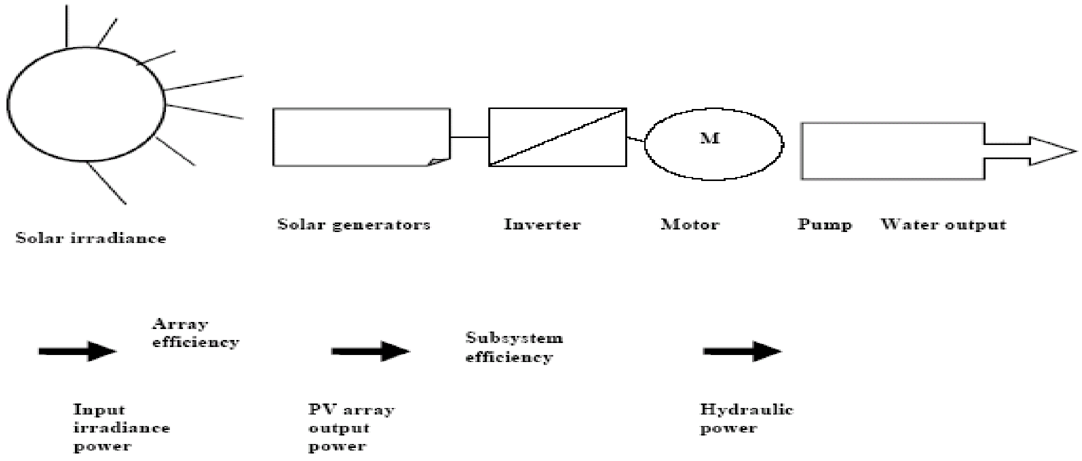

Fig. 1. Solar water pump system.

Renewable energy is the term used to describe a wide range of naturally occurring, replenishing energy sources. The use of renewable energy sources and the rational use of energy are the fundamental inputs for any responsible energy policy. Figure 1 summarises solar water pumps application. Figure 2 shows solar cells, module solar panel and solar array.

Over the years, all parts of a commercial refrigerator, such as the compressor, heat exchangers, refrigerant, and packaging, have been improved considerably due to the extensive research and development efforts carried out by academia and industry. However, the achieved and anticipated improvement in conventional refrigeration technology are incremental since this technology is already nearing its fundamentals limit of energy efficiency is described is 'magnetic refrigeration' which is an evolving cooling technology. The word 'green' designates more than a colour. It is a way of life, one that is becoming more and more common throughout the world. An interesting topic on 'sustainable technologies for a greener world' details about what each technology is and how it achieves green goals. Recently, conventional chillers using absorption technology consume energy for hot water generator but absorption chillers carry no energy saving. With the aim of providing a single point solution for this dual purpose application, a product is launched but can provide simultaneous chilling and heating using its vapour absorption technology with 40% saving in heating energy. Using energy efficiency and managing customer energy use has become an integral and valuable exercise. The reason for this is green technology helps to sustain life on earth. This not only applies to humans but to plants, animals and the rest of the ecosystem. Energy prices and consumption will always be on an upward trajectory. In fact, energy costs have steadily risen over last decade and are expected to carry on doing so as consumption grows. This approach discusses the potential for such integrated systems in the stationary and portable power market in response to the critical need for a cleaner energy technology for communities. Throughout the theme several issues relating to renewable energies, environment and sustainable development are examined from both current and future perspectives.

Table 3
The possible shares of different renewable energies in diverse climatic zones produced on an energy farm.

Climatic region	Energy source	Power production (% of total need)	Heat production (% of the total need)	Biomass need (total area)	Biomass area (5 of the total area)
Northern and Central Europe	Solar 200 m^2	7	15	60	12
	Wind 100 kW	100	-		
	Biomass	100	105		
South Europe	Solar 250 m^2	12.7	40	36	48
	Wind 100 kW	100	-		
	Biomass	70	65		
Northern Africa Sahara	Solar 300 m^2	21	90	14	1.2
	Wind 100 kW	75	-		
	Biomass	25	29		
Equatorial Region	Solar 200 m^2	18.2	37.5	45	
	Wind 100 kW	45	-		
	Biomass	70	80		

For a northern European climate, which is characterised by an average annual solar irradiance of 150 Wm^{-2}, the mean power production from a photovoltaic component of 13% conversion efficiency is approximately 20 Wm^{-2}. For an average wind speed of 5 ms^{-1}, the power produced by a micro wind turbine will be of a similar order of magnitude, though with a different profile shape. In the UK, for example, a typical office building will have a demand in the order of 300 kWhm^{-2}yr^{-1}. This translates into approximately 50 Wm^{-2} of façade, which is twice as much as the available renewable energies. Thus, the aim is to utilise energy efficiency measures in order to reduce the overall energy consumption and adjust the demand profiles to be met by renewable energies. For instance, this approach can be applied to greenhouses, which use solar energy to provide indoor environmental quality. The greenhouse effect is one result of the differing properties of heat radiation when it is generated at different temperatures. Objects inside the greenhouse, or any other building, such as plants, re-radiate the heat or absorb it. Because the objects inside the greenhouse are at a lower temperature than the sun, the re-radiated heat is of longer wavelengths, and cannot penetrate the glass. This re-radiated heat is trapped and causes the temperature inside the greenhouse to rise. Note that the atmosphere surrounding the earth, also, behaves as a large greenhouse around the world. Changes to the gases in the atmosphere, such as increased carbon dioxide content from the burning of fossil fuels, can act like a layer of glass and reduce the quantity of heat that the planet earth would otherwise radiate back into space. This particular greenhouse effect, therefore, contributes to global warming. The application of greenhouses for plants growth can be considered one of the measures in the success of solving this problem. Maximising the efficiency gained from a greenhouse can be achieved using various approaches, employing different techniques that could be applied at the design, construction and operational stages. The development of greenhouses could be a solution to farming industry and food security.

Solar Cell Solar Module Solar PV Panels Solar PV Arrays

Fig. 2. Solar photovoltaic arrays.

2.1. Policy recommendations for a sustainable energy future

Energy is the vital input for economic and social development of any country. Its sustainability is an important factor to be considered. The urban areas depend, to a large extent, on commercial energy sources. The rural areas use non-commercial sources like firewood and agricultural wastes. With the present day trends for improving the quality of life and sustenance of mankind, environmental issues are considered highly important. In this context, the term energy loss has no significant technical meaning. Instead, the exergy loss has to be considered, as destruction of exergy is possible. Hence, exergy loss minimisation will help in sustainability. In the process of developing, there are two options to manage energy resources: (1) End use matching/demand side management, which focuses on the utilities. The mode of obtaining this is decided based on economic terms. It is, therefore, a quantitative approach. (2) Supply side management, which focuses on the renewable energy resource and methods of utilising it. This is decided based on thermodynamic consideration having the resource-user temperature or exergy destruction as the objective criteria. It is, therefore, a qualitative approach. The two options are explained schematically in Figure 3. The exergy-based energy, developed with supply side perspective is shown in Figure 4.

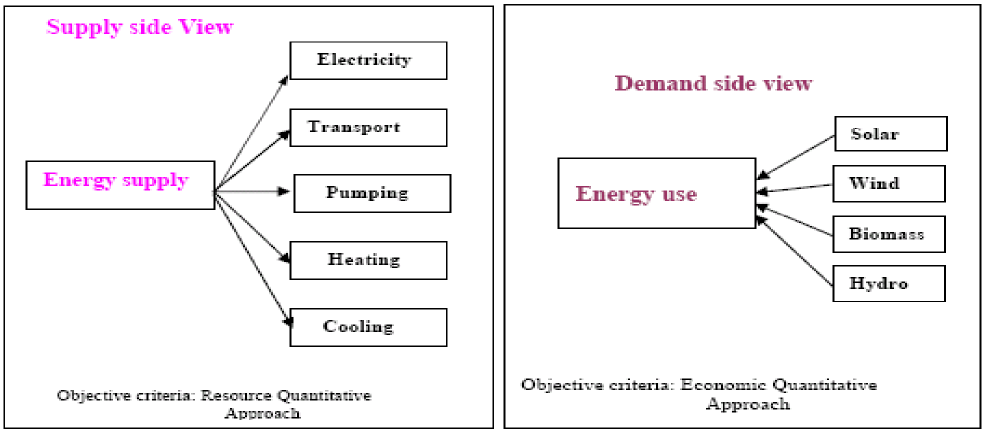

Fig. 3. Supply side and demand side management approach for energy.

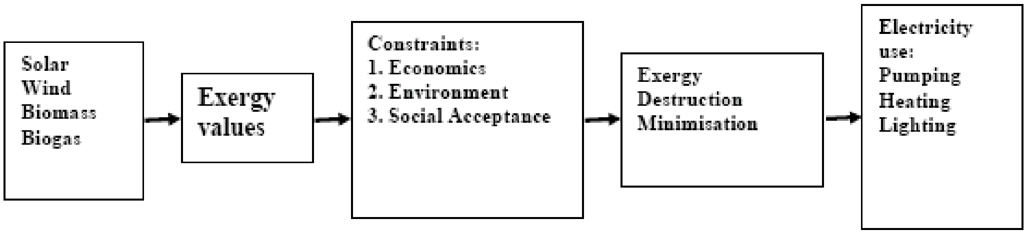

Fig. 4. Exergy based optimal energy model.

The following policy measures had been identified:

- Clear environmental and social objectives for energy market liberalisation, including a commitment to energy efficiency and renewables.
- Economic, institutional and regulatory frameworks, which encourage the transition to total energy services.
- Economic measures to encourage utility investment in energy efficiency (e.g., levies on fuel bills).
- Incentives for demand side management, including grants for low-income households, expert advice and training, standards for appliances and buildings and tax incentives.
- Research and development funding for renewable energy technologies not yet commercially viable.
- Continued institutional support for new renewables (such as standard cost-reflective payments and obligation on utilities to buy).
- Ecological tax reform to internalise external environmental and social costs within energy prices.
- Planning for sensitive development and public acceptability for renewable energy.

2.2. Ecosystem engineering

Ecologists have traditionally explained the distribution and abundance of organisms by such factors as food availability, presence of enemies, competition and climate. It is now apparent, however, that other factors are also important. One of these other factors is "ecosystem engineering", which happens when certain organisms (called "ecosystem engineers") create, modify and maintain habitats.

Ecosystem engineering can alter the distribution and abundance of large numbers of plants and animals, and significantly modify biodiversity (Jones et al., 1994, 1997; Wright et al., 2002; Lill and Marquis, 2003). The best known examples of ecosystem engineers are humans (Homo sapiens). However, this study will focus on non-human ecosystem engineers and review the many ways they alter the distribution and abundance of other organisms.

2.3. Ecosystem engineers

Physical ecosystem engineers are organisms that create, modify or maintain habitats (or microhabitats) by causing physical state changes in biotic and abiotic materials that, directly or indirectly, modulate the availability of resources to other species (Jones et al., 1994, 1997). Ecosystem engineering is the "creation, modification and maintenance of habitats [and microhabitats] by organisms (Gutiérrez et al., 2003)".

Ecosystem engineering appears to be very common in the natural world (see examples below); however, because most organisms affect the physical environment in some way, it seems unwise to call all of them "ecosystem engineers". Instead, Reichman and Seablom, 2002ab) propose restricting the term "ecosystem engineers" to keystone species, such as beaver and pocket gophers that very strongly affect other organisms. On the other hand, the term "ecosystem engineering" can be used to describe the activities of a wide variety of organisms whenever they engage in activities that physically create, modify or maintain habitats, even those which are not influential enough to be considered ecosystem engineers (Wilby, 2002).

2.4. Allogenic and autogenic ecosystem engineers

Jones et al., 1994 distinguished between two different kinds of physical ecosystem engineers:

1. Allogenic engineers "change the environment by transforming living or nonliving materials from one physical state to another, via mechanical or other means".
2. Autogenic engineers "change the environment via their own physical structures, i.e., their living and dead tissues". As they grow and become larger, their living and dead tissues create habitats for other organisms to live on or in.

We will now look examples of these two kinds of physical ecosystem engineers and their effects on the abundance and distribution of other species.

2.5. Examples of allogenic engineering

The Beaver (Castor fibre and Castor Canadensis) is an important allogenic engineer of the Northern Hemisphere. It transforms living trees into dead trees by cutting them down, and then uses them to dam streams and create ponds. Beaver engineering alters the distribution and abundance of many different organisms, including birds, reptiles, amphibians, plants, and insects; and also increases biodiversity at the landscape scale (Wright et al., 2002). For more details, see our reviews: Beaver and Birds, Beaver and Reptiles, Beaver and Amphibians, Beaver and Invertebrates, Beaver and Trees, and Ecology of the Beaver.

The Indian Crested Porcupine (Hystrix indica) digs for its food (roots and tubers) in the ground, and so creates soil pits that persist for decades. Seeds, water and other organic material accumulate in these pits and create microhabitats that have increased plant abundance and diversity (Alkon, 1999; Wilby et al., 2001). For example, Boeken et al., 1995 found that the biomass, density and species richness of plants was higher in porcupine digging pits than at nearby control plots in undisturbed soil.

Shelter-building caterpillars construct leaf shelters such as leaf rolls, ties, folds and tents (Lill and Marquis, 2003). These new microhabitats (the leaf shelters) are used concurrently and subsequently by many other arthropods. A study of shelter-building caterpillars on White Oak (Quercus Alba) saplings found that leaf shelters increased arthropod biodiversity on the entire plant (Lill and Marquis, 2003).

Harvester Ants (Messor ebeninus) build mounds to house their colonies. In most cases, the incidence and abundance of plant species is higher on these Harvester Ant nest mounds than on adjacent undisturbed soil (Wilby et al., 2001).

In Africa, herds of domestic cattle and wild ungulates help human malaria mosquito vectors increase in abundance by physically creating microhabitats for them to breed in. The engineering occurs when cattle and wild ungulates visit watering holes, where they leave a multitude of large, deep hoof marks in the wet soil. These hoof marks fill with rain or seep water and are rapidly colonised by Anopheles arabiensis and Anopheles gambiae, malaria mosquitoes that breed in temporary, non-permanent pools of water. Peters, 1992 shows a photo of such muddy hoof-prints near a malaria-infected village in Mali, where both species of mosquitoes were collected.

When woodpeckers and other birds excavate holes in which to nest, they create homes not only for themselves but for many other animals. In Spain, for example, the European Bee-eater (Merops apiaster) excavates deep nesting burrows in the ground and in vertical cliffs, that are subsequently used for breeding by at least 12 other species of birds after the bee-eater has abandoned them (Casas-Crivillé and Valera, 2005). While digging a burrow, each bee-eater pair removes an estimated 13 kilograms of soil. Since the bee-eater nests in colonies, the combined excavations of many pairs digging their burrows results in the redistribution of large amounts of soil and an acceleration of geologic processes such as soil erosion and the collapse of banks (Casas-Crivillé and Valera, 2005).

2.6. Examples of autogenic engineering

Trees, corals, and giant kelps are good examples of autogenic engineers. As they grow and become larger, their living and dead tissues create habitats for other organisms to live on or in.

When plants grow on tree trunks or branches rather than in the ground, they are called epiphytes. In the tropics, epiphytes are especially common, where they represent up to 25% of all vascular plant species (Nieder et al., 2001). A survey of 118 individuals of the Stilt Palm (Socratea exorrhiza) in Panama found 701 vascular epiphytes of 66 species (Zotz and Vollrath, 2003). Epiphytes and the animals associated with them form unique canopy communities in the tropics, made possible by the autogenic engineering of trees which create habitats (tree trunks and branches) for these organisms.

Epiphytes and canopy communities are also found in temperate forests. For example, Coast Redwood (Sequoia sempervirens) often supports significant communities of epiphytes because the large size and great height of these trees make them excellent structures for other plants to grow on. Epiphytes growing high in the canopy of Redwood trees include various species of broadleaf trees, shrubs and ferns (Sillett and Van Pelt, 2000). One California bay (Umbellularia californica [Lauraceae]) found growing in the crown of a Redwood is the highest recorded epiphytic tree in the world, growing out of a knothole in the Redwood located 98.3 meters above the ground (Sillett and Van Pelt, 2000). Many animals also make their home in or on redwood trees (for details of plants and animals living in the canopy of Coast Redwoods, see our review: Ecology of the Coast Redwood).

Lianas (woody vines) are also autogenic engineers. For example, when lianas grow through a forest canopy, they connect trees together, forming arboreal pathways that monkeys and other animals can use to travel without having to descend to the ground (Charles-Dominique, 1971; Charles-Dominique et al., 1981). Shell production by mollusks is another example of autogenic engineering (Gutiérrez et al., 2003). In aquatic habitats, "mollusk shells are abundant, persistent, ubiquitous structures" that is used by other organisms for attachment, as refuges from "predation, physical or physiological stress", and to "control transport of solutes and particles in the benthic environment (Gutiérrez et al., 2003)".

My collaborative research involves empirical studies on the effects of engineers, the development of concepts and models of ecosystem engineering, syntheses of the existing literature, and forging connections between ecosystem engineering and other disciplines (geomorphology, evolutionary biology, and environmental management). Research in this area is helping us understand how species – including humans as ecosystem engineers – can affect the abundance and diversity of species and the functioning of ecosystems (Figure 5).

2.7. Ecosystem engineers and biodiversity

By creating, modifying and maintaining habitats, ecosystem engineers disturb the natural environment. This disturbance will usually cause some species to increase in abundance and others to decrease in abundance. Within just the area (patch) where the engineering occurs, biodiversity can be either increased or decreased, depending on which changes were made. However, if we look at the effects of the engineering at a larger spatial scale (i.e., the landscape scale), a view that includes not only the patch of habitat that was engineered but surrounding non-engineered habitats as well, it will be seen that ecosystem engineering makes the ecological landscape more heterogeneous.

An important question is, "Does ecosystem engineering result in greater biodiversity at the landscape scale?" In the Adirondack region of New York (Wright et al., 2002) found that beaver engineering increased species richness (one measure of biodiversity) of plants at the landscape scale, but these researchers concluded that not all engineers might have such an effect. Based on their beaver research, they proposed that two requirements must be fulfilled in order for ecosystem engineers to increase species richness at the landscape scale: (1) "an engineer must create a patch with a combination of conditions not present elsewhere in the landscape", and (2) "there must be species that live in the engineered patches that are not present in patches unmodified by the engineer". In addition, the engineered patches should not dominate the landscape and become so numerous that non-engineered patches become too small or too few to support their full complement of species (Wright et al., 2002).

Of course, there can be exceptions. For example, if a species is found in both engineered and non-engineered patches but the non-engineered patch is a habitat of high mortality where reproduction usually fails, the species can be dependent on the engineered habitat for survival (Wright et al., 2002).

Many organisms build, modify or destroy physical structures in the environment. For example, both beavers and the Army Corps of Engineers build dams. Beaver dams and many other physical structures have important ecological effects on other species because these structures create habitat, control the amount of abiotic resources that other species can use, and can ameliorate or exacerbate abiotic conditions that affect organisms. Rock-eating snails in the Negev Desert control the amount of soil for plants. Desert Isopods control soil erosion and remove salts that decrease soil fertility for plants. Desert porcupines dig pits that trap water and seeds, making an ideal place for annual plants to grow. There are hundreds of other examples of organisms physically modifying the environment in all sorts of ecosystems. And yet, in general we know far less about these engineers and their ecological effects than we know about the effects of predation or competition for resources among organisms.

How and why do engineers have effects? How important are these effects? How similar are different engineers? How can we quantify, compare and model engineering effects?

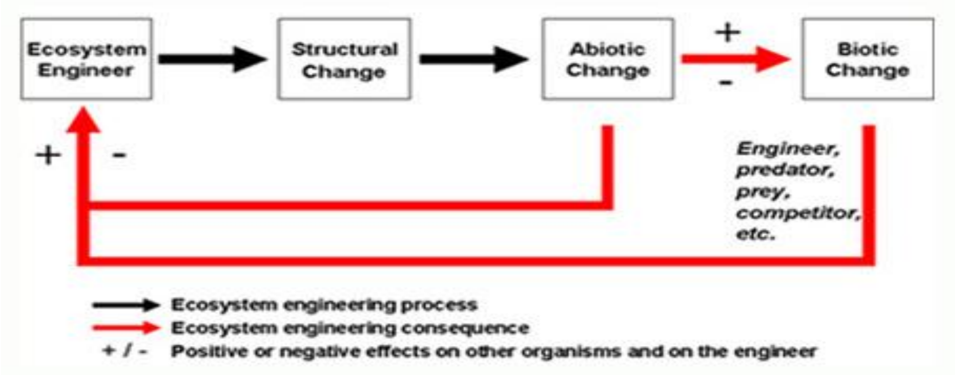

Fig. 5. General pathways of physical ecosystem engineering.

Credit: Gabriel J. Miller, University of Florida, 2007.

Fig. 6. A Live Oak tree (Quercus virginiana) is an example of an autogenic engineer - its presence and physical structure provides and modifies habitat.

Ecological engineering is defined as the creation, modification, and maintenance of environments by plants and animals. All organisms affect their environment in some small way, but ecological engineers make significant changes such as regulating the availability of essential resources (like food, water, and shelter) or altering natural processes (such as water flow). By modifying their habitats, ecological engineers also influence the occurrence of plants and animals in natural communities. Scientists recognise two types of ecological engineers: autogenic and allogenic.

Autogenic engineers provide or modify habitat through their presence or physical structure (these are typically plants). An example of an autogenic engineer is a Live Oak tree (Quercus virginiana, Figure 6). Environmental conditions beneath the tree's limbs and leaves (i.e., its canopy) are different than conditions outside the tree's canopy. In summer, for example, light levels are typically lower and temperatures are cooler under the protective cover of the canopy than in areas beyond the canopy.

2.8. Ecological engineering

The term, "ecological engineering," was first coined by Howard T. Odum in 1962. Howard Odum is now professor emeritus at the University of Florida, where his work in systems ecology has flourished.

Ecological engineering, he wrote, is "those cases where the energy supplied by man is small relative to the natural sources but sufficient to produce large effects in the resulting patterns and processes". (H.T. Odum, 1962, "Man and Ecosystem" Proceedings, Lockwood Conference on the Suburban Forest and Ecology (Bulletin Connecticut Agric. Station). Another definition that follows from that relates to ecosystem management by human society (Center for Wetlands, University of Florida): "Ecological engineering is the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both. It involves the design, construction and management of ecosystems that have value to both humans and the environment. Ecological engineering combines basic and applied science from engineering, ecology, economics, and natural sciences for the restoration and construction of aquatic and terrestrial ecosystems. The field is increasing in breadth and depth as more opportunities to design and use ecosystems as interfaces between technology and environment are explored".

Another definition seeks to use the ecological paradigm to construct ecologies to solve vexing world-class problems, such as pollution: It is predicated on the believe that the self-organising order found in stable ecosystems is so universal that it can be applied as an engineering discipline to solve the pressing problems of global pollution, food production and efficient resource-utilisation, while providing a high quality of life for all human society (David Del Porto).

In this definition, the ecological paradigm reveals how to safely utilise the polluting components of unwanted residuals, or "wastes", to ultimately grow green plants that have value to human society, but not at the expense of aquatic and terrestrial ecosystems. Planning, design and construction (with the ecological paradigm as a template) are the work of ecological engineers.

An impressive array of animals function as ecosystem engineers in streams through a variety of activities, ‘’ranging from nest digging by anadromous salmon to benthic foraging by South American fishes, and from the burrowing of aquatic insects to the trampling of hippos’’. These ecosystem engineers have local impacts on benthic habitat and also strongly affect downstream fluxes of nutrients and other resources. The impacts of ecosystem engineers are most likely some function of their behaviour, size, and population density, modulated by the abiotic conditions of the stream. In streams, subsidies often control the body size and density of ecosystem engineers, while hydrologic energy controls their distribution, density, and life-history attributes, the habitats they create, and the resources and organisms they affect. Because ecosystem engineers can profoundly affect stream ecosystems, and because they themselves can be significantly affected positively or negatively by human activities, understanding ecosystem engineering in streams is increasingly important for the management of these ecosystems.

Stream dynamics are controlled by a combination of abiotic and biotic factors. Disturbances such as floods control the characteristics of stream ecosystems and communities, creating a dynamic and complex mosaic of differently aged patches. Streams exhibit high longitudinal connectivity—downstream flows and movements of organisms move nutrients, particles, organisms, and other matter from upland to lowland streams. Streams often have high lateral connectivity as well: Reciprocal subsidies of matter and organisms connect riparian and stream habitats. The activities of animals that physically modify the environment are also critical to stream processes and dynamics. Beavers build dams; chironomids burrow in sediments; salmon dig nests. In these and many other ways, animals affect stream ecosystems by physically modifying habitats or resources. These animals are ecosystem engineers, broadly defined as “organisms that directly or indirectly control the availability of resources to other organisms” through the “physical modification, maintenance, or creation of habitats”.

Ecosystem engineers can modify a variety of stream ecosystem attributes. Perhaps most frequently considered (apart from the beaver, and Castor Canadensis) are those that physically modify benthic habitats. However, ecosystem engineers not only have local benthic impacts but also can fundamentally influence a diverse array of stream ecosystem components. For example, ecosystem engineers can impact hydrological dynamics of rivers; specifically, movements of crocodiles (Crocodylus spp.), hippos (Hippopotamus amphibious), and wildebeests (Equus burchelli) can mix the water column of stagnant pools in African rivers, preventing development of anoxic conditions. Ecosystem engineers also alter the dynamics of nutrients and particulate matter, key resources for many stream organisms. Thus, it would seem that ecosystem engineers can influence virtually all aspects of stream ecology. For the purposes of this communication, I will focus on animals as ecosystem engineers in streams, even though many ecosystem engineers of stream habitats are not animals. For example, riparian trees shade attached algae (i.e., periphyton) in streams and provides large woody debris that serves as structure for stream organisms and changes stream morphology.

Although stream ecosystems provide many of the best appreciated, and potentially the most numerous, examples of ecosystem engineers, there has been virtually no development of a conceptual framework to help understand how, where, and when ecosystem engineers are important to stream ecosystems and communities. Ecosystem engineers have the potential to affect most aspects of stream dynamics, but they are not important in all systems. Thus, a major challenge in understanding the roles of ecosystem engineers in streams (and in all ecosystems, for that matter) is to discern the context dependency of their effects.

Animal Ecosystem Engineers in Streams Stream dynamics are controlled by a combination of abiotic and biotic factors. Disturbances such as floods control the characteristics of stream ecosystems and communities, creating a dynamic and complex mosaic of differently aged patches. Streams exhibit high longitudinal connectivity—downstream flows and movements of organisms move nutrients, particles, organisms, and other matter from upland to lowland streams. Lateral connectivity as well: Reciprocal subsidies of matter and organisms connect riparian and stream habitats. The activities of animals that physically modify the environment are also critical to stream processes and dynamics.

3. Conversion of biowastes to platform chemicals

- HMF contains a furan group, an aldehyde and a primary alcohol group
- CMF contains a furan group, an aldehyde and a chloromethyl group
- The primary alcohol group can be oxidised, esterified, etherified, substituted, etc.
- The chloromethyl group can be hydrolysed, condensed, etherified, etc.
- The aldehyde can be oxidised, reduced, condensed, etc.
- The electron rich furan ring can undergo Diels-Alder cycloaddition reactions
- The Food and Drug Administration (FDA) identified HMF and CMF as platform chemicals because of:-
- Highly selective synthetic preparation
- They are building blocks for 20 performance polymers and 125 custom chemicals (Figure 7)

3.1. Concept

Develop “green energy’’ from renewable and abundant sources like biowastes, etc., will not only relief us from depending on hostile foreign sources for energy but also foster economic development opportunities (Figure 8).

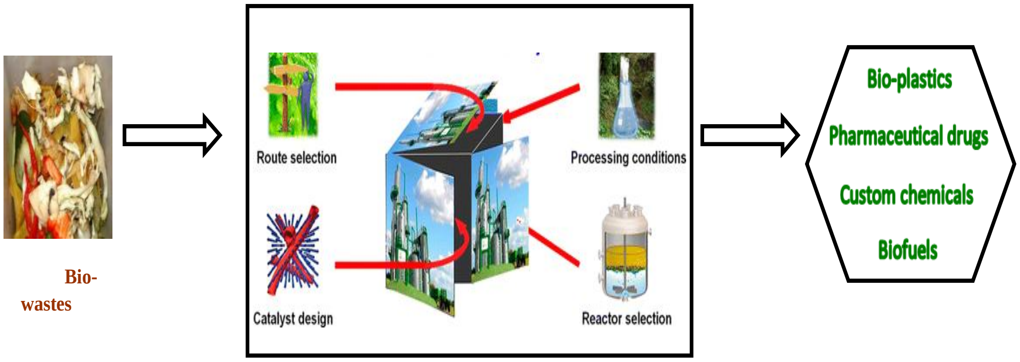

Fig. 7. Catalytic conversions of biowastes to platform chemicals.

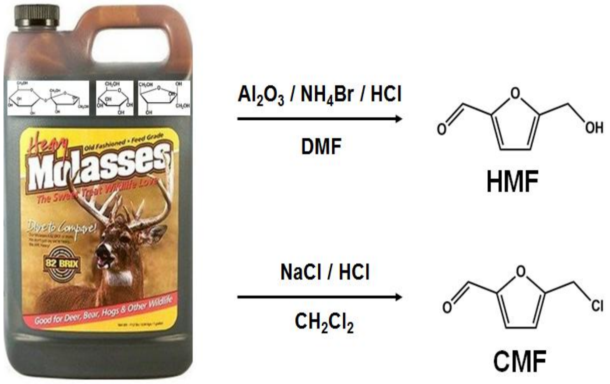

Fig. 8. Green and efficient approaches from biowastes to two value-added chemicals.

3.2. Objectives

I. Develop green energy technology
II. Develop competitive research in emerging technology

3.3. Merits

- This new green energy initiative generates sustainable value-added chemicals.
- The use of dirt-cheap biowastes as industrial resources will help remediate environmental pollution and generate profitable income
- Build smart partnerships with established entities…

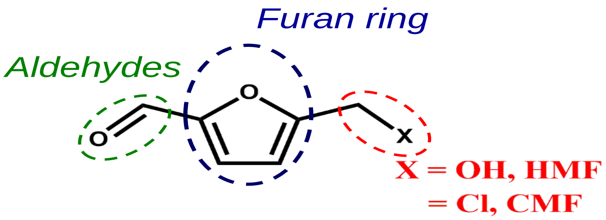

Fig. 9. The rich chemistry of furfurals versatility of the XMFs as today's platform chemicals.

- Dimethyfurfural (DMF), and Dimethyltetrahydrofuran (DMTHF)
- Ethoxymethylfurfural (EMF) is value-added chemicals that can be used as organic solvents, fuel bio-additives or independent biofuels.
- DMF, DMTHF and EMF are candidates receiving serious consideration to replace bio-ethanol because of their superior properties (high energy density, water solubility, etc.) (Figure 9).

The energy conservation scenarios include rational use of energy policies in all economy sectors and the use of combined heat and power systems, which are able to add to energy savings from the autonomous power plants. Electricity from renewable energy sources is by definition the environmental green product. Hence, a renewable energy certificate system, as recommended by the World Summit, is an essential basis for all policy systems, independent of the renewable energy support scheme. It is, therefore, important that all parties involved support the renewable energy certificate system in place if it is to work as planned. Moreover, existing renewable energy technologies (RETs) could play a significant mitigating role, but the economic and political climate will have to change first. Climate change is real. It is happening now, and the GHGs produced by human activities are significantly contributing to it. The predicted global temperature increase of between 1.5 and 4.5°C could lead to potentially catastrophic environmental impacts. These include sea level rise, increased frequency of extreme weather events, floods, droughts, disease migration from various places and possible stalling of the Gulf Stream. This has led scientists to argue that climate change issues are not ones that politicians can afford to ignore, and policy makers tend to agree. However, reaching international agreements on climate change policies is no trivial task as the difficulty in ratifying the Kyoto Protocol has proved. Figures 10-13 summarise biofuel production.

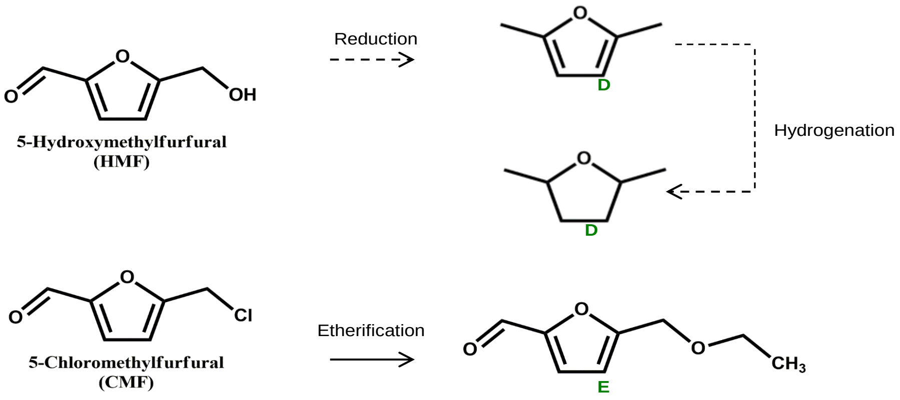

Fig. 10. Simple biofuels from the XMFs.

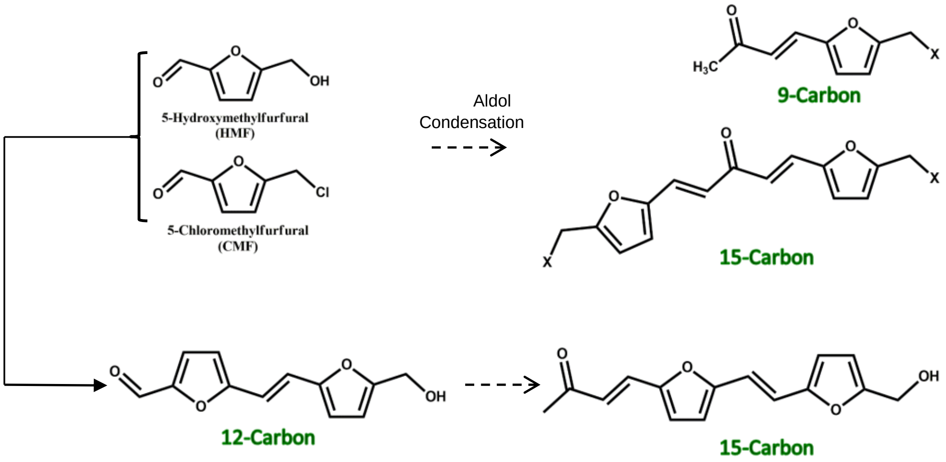

Fig. 11. Biofuel precursors by Aldol condensation 9-, 12-, and 15-C Vinyl condensates.

- Long carbon chain vinyl derivatives can be synthesized by simple Aldol condensations
- Oxygenated hydrocarbon fuels obtained via reduction, hydrogenation and ring opening
- Scientists developed two simple oxidation protocols for making versatile polymeric monomers; furan dialdehyde and furan dicarboxylic acid (FCDA) – an analogue of widely terephthahlic acid.
- Several polymers can produced via esterification or condensation reactions as shown in Figures 10-13.

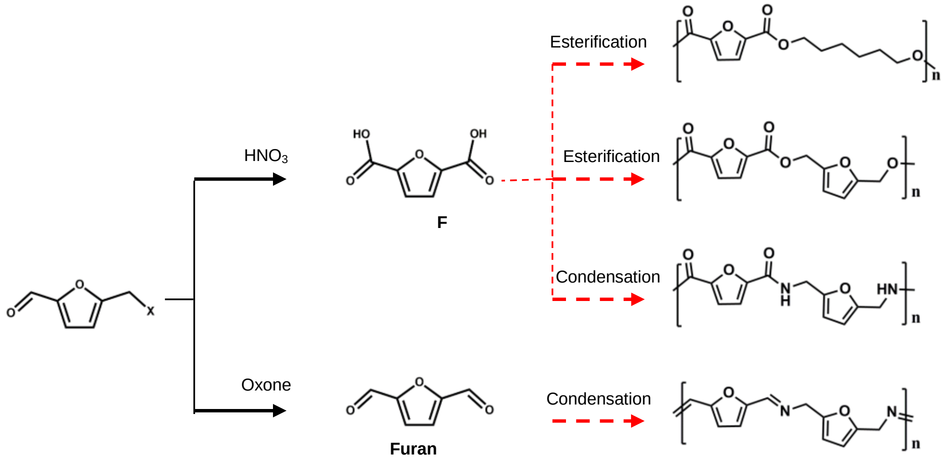

Fig. 12. Visionary from Biowastes to furan-based biopolymers.

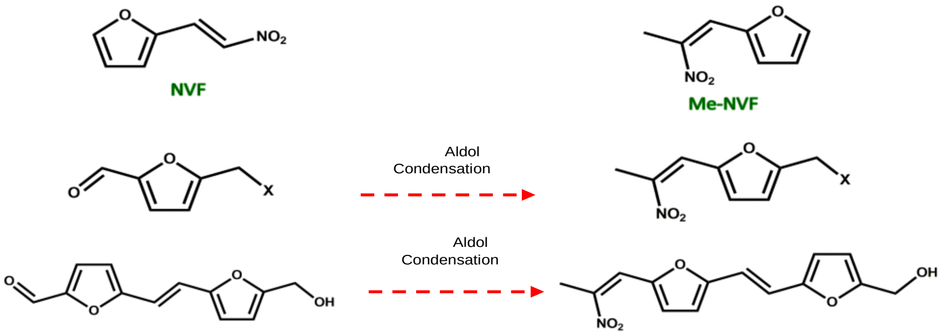

Fig. 13. Simple furan-based biopharmaceuticals from furfurals to Nitrovinylfurans (NVFs).

- Nitrovinylfuran (NVF) drugs are effective inhibitors of viruses, ectoparasites (blood sucking) and fungi
- Known NVFs have commonly been synthesized from furfurals
- It will be interesting to study the impact of chloromethyl, hydroxymethyl, and other complex derivatives of the NVFs shown in the schemes above.

Bright industrial future for the XMFs

- The XMFs have clearly defined application in diversified industrial fields
- However, The XMF synthetic methods amenable for industrial application should be sustainable and efficient.
- Our methods fit requirements for industrial application because of simplicity, affordability, sustainability and use of the cheapest and most abundant raw materials.
- The HMF and CMF are synthesized from molasses in one step and in high yield.

4. Ecosystems

An ecosystem consists of the biological community that occurs in some locale, and the physical and chemical factors that make up its non-living or abiotic environment. There are many examples of ecosystems -- a pond, a forest, an estuary, grassland. The boundaries are not fixed in any objective way, although sometimes they seem obvious, as with the shoreline of a small pond. Usually the boundaries of an ecosystem are chosen for practical reasons having to do with the goals of the particular study.

The study of ecosystems mainly consists of the study of certain processes that link the living, or biotic, components to the non-living, or abiotic, components. Energy transformations and biogeochemical cycling are the main processes that comprise the field of ecosystem ecology. As we learned earlier, ecology generally is defined as the interactions of organisms with one another and with the environment in which they occur. We can study ecology at the level of the individual, the population, the community, and the ecosystem (Table 4).

Table 4
Biotic components to the non-living, or abiotic components.

Abiotic components	Biotic components
Sunlight	Primary producers
Temperature	Herbivores
Precipitation	Carnivores
Water or moisture	Omnivores
Soil or water chemistry (e.g., P, NH_4+), etc.	Detritivores, etc.

All of these vary over space/time

Studies of individuals are concerned mostly about physiology, reproduction, development or behaviour, and studies of populations usually focus on the habitat and resource needs of individual species, their group behaviours, population growth, and what limits their abundance or causes extinction. Studies of communities examine how populations of many species interact with one another, such as predators and their prey, or competitors that share common needs or resources.

In ecosystem ecology we put all of this together and, insofar as we can, we try to understand how the system operates as a whole. This means that, rather than worrying mainly about particular species, we try to focus on major functional aspects of the system. These functional aspects include such things as the amount of energy that is produced by photosynthesis, how energy or materials flow along the many steps in a food chain, or what controls the rate of decomposition of materials or the rate at which nutrients are recycled in the system.

4.1. Components of an ecosystem

You are already familiar with the parts of an ecosystem. You have learned about climate and soils from past lectures. From this course and from general knowledge, you have a basic understanding of the diversity of plants and animals, and how plants and animals and microbes obtain water, nutrients, and food. We can clarify the parts of an ecosystem by listing them under the headings "abiotic" and "biotic".

By and large, this set of environmental factors is important almost everywhere, in all ecosystems. Usually, biological communities include the "functional groupings" shown in Figure 13. A functional group is a biological category composed of organisms that perform mostly the same kind of function in the system; for example, all the photosynthetic plants or primary producers form a functional group. Membership in the functional group does not depend very much on who the actual players (species) happen to be, only on what function they perform in the ecosystem.

4.2. Processes of ecosystems

In Figure 14 with the plants, zebra, lion, and so forth illustrates the two main ideas about how ecosystems function: ecosystems have energy flows and ecosystems cycle materials. These two processes are linked, but they are not quite the same (Figure 14).

Energy enters the biological system as light energy, or photons, is transformed into chemical energy in organic molecules by cellular processes including photosynthesis and respiration, and ultimately is converted to heat energy. This energy is dissipated, meaning it is lost to the system as heat; once it is lost it cannot be recycled. Without the continued input of solar energy, biological systems would quickly shut down. Thus the earth is an open system with respect to energy.

Elements such as carbon, nitrogen, or phosphorus enter living organisms in a variety of ways. Plants obtain elements from the surrounding atmosphere, water, or soils. Animals may also obtain elements directly from the physical environment, but usually they obtain these mainly as a consequence of consuming other organisms. These materials are transformed biochemically within the bodies of organisms, but sooner or later, due to excretion or decomposition, they are returned to an inorganic state. Often bacteria complete this process, through the process called decomposition or mineralisation (see previous literature on microbes).

During decomposition these materials are not destroyed or lost, so the earth is a closed system with respect to elements (with the exception of a meteorite entering the system now and then). The elements are cycled endlessly between their biotic and abiotic states within ecosystems. Those elements whose supply tends to limit biological activity are called nutrients.

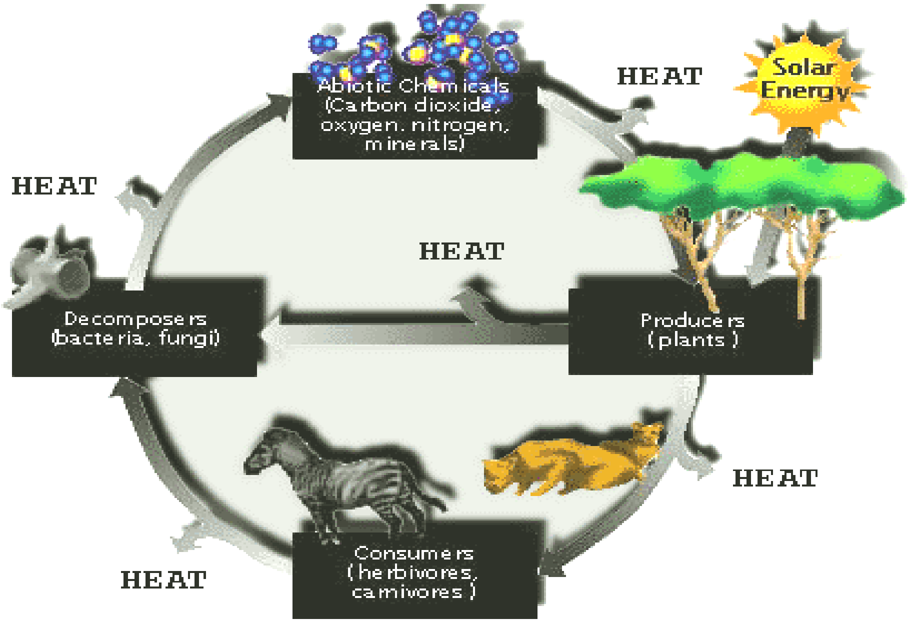

Fig. 14. Energy flows and material cycles.

4.3. The transformation of energy

The transformations of energy in an ecosystem begin first with the input of energy from the sun. Energy from the sun is captured by the process of photosynthesis. Carbon dioxide (CO_2) is combined with hydrogen (derived from the splitting of water molecules) to produce carbohydrates (CHO). Energy is stored in the high energy bonds of adenosine triphosphate or ATP (see lecture on photosynthesis).

The prophet Isaah said "all flesh is grass", earning him the title of first ecologist, because virtually all energy available to organisms originates in plants. Because it is the first step in the production of energy for living things, it is called primary production (for a primer on photosynthesis). Herbivores obtain their energy by consuming plants or plant products, carnivores eat herbivores, and detritivores consume the droppings and carcasses of us all.

Figure 15 portrays a simple food chain, in which energy from the sun, captured by plant photosynthesis, flows from trophic level to trophic level via the food chain. A trophic level is composed of organisms that make a living in the same way that is they are all primary producers (plants), primary consumers (herbivores) or secondary consumers (carnivores). Dead tissue and waste products are produced at all levels. Scavengers, detritivores, and decomposers collectively account for the use of all such "waste" -- consumers of carcasses and fallen leaves may be other animals, such as crows and beetles, but ultimately it is the microbes that finish the job of decomposition. Not surprisingly, the amount of primary production varies a great deal from place to place, due to differences in the amount of solar radiation and the availability of nutrients and water.

For reasons that we will explore more fully in subsequent lectures, energy transfer through the food chain is inefficient. This means that less energy is available at the herbivore level than at the primary producer level, less yet at the carnivore level, and so on. The result is a pyramid of energy, with important implications for understanding the quantity of life that can be supported.

Usually when we think of food chains we visualise green plants, herbivores, and so on. These are referred to as grazer food chains, because living plants are directly consumed. In many circumstances the principal energy input is not green plants but dead organic matter. These are called detritus food chains. Examples include the forest floor or a woodland stream in a forested area, a salt marsh, and most obviously, the ocean floor in very deep areas where all sunlight is extinguished 1000's of meters above. In subsequent lectures we shall return to these important issues concerning energy flow.

Finally, although we have been talking about food chains, in reality the organisation of biological systems is much more complicated than can be represented by a simple "chain". There are many food links and chains in an ecosystem, and we refer to all of these linkages as a food web. Food webs can be very complicated, where it appears that "everything is connected to everything else" and it is important to understand what the most important linkages are in any particular food web.

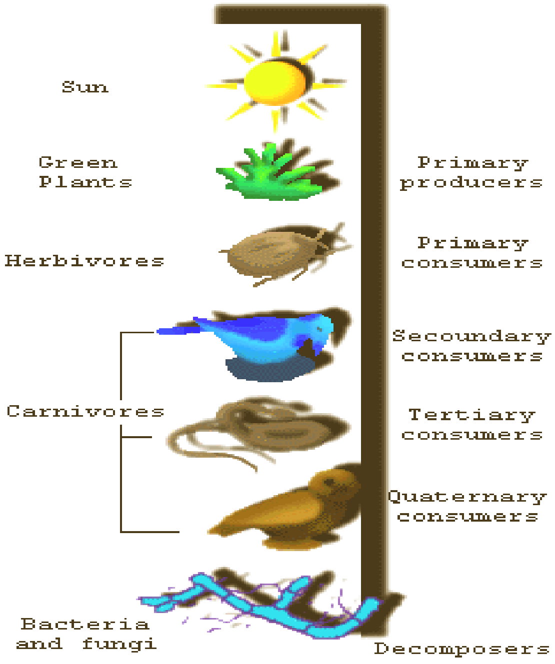

Fig. 15. The Portrays a simple food chain, in which energy from the sun.

4.4. Biogeochemistry

How can we study which of these linkages in a food web are most important? One obvious way is to study the flow of energy or the cycling of elements. For example, the cycling of elements is controlled in part by organisms, which store or transform elements, and in part by the chemistry and geology of the natural world. The terms Biogeochemistry is defined as the study of how living systems influence, and is controlled by, the geology and chemistry of the earth. Thus biogeochemistry encompasses many aspects of the abiotic and biotic world that we live in.

There are several main principles and tools that biogeochemists use to study earth systems. Most of the major environmental problems that we face in our world today can be analysed using biogeochemical principles and tools. These problems include global warming, acid rain, environmental pollution, and increasing greenhouse gases. The principles and tools that we use can be broken down into 3 major components: element ratios, mass balance, and element cycling.

1. Element ratios

In biological systems, we refer to important elements as "conservative". These elements are often nutrients. By "conservative" we mean that an organism can change only slightly the amount of these elements in their tissues if they are to remain in good health. It is easiest to think of these conservative elements in relation to other important elements in the organism. For example, in healthy algae the elements C, N, P, and Fe have the following ratio, called the Redfield ratio after the oceanographer who discovered it:

$$C: N: P: Fe = 106: 16: 1: 0.01$$

Once we know these ratios, we can compare them to the ratios that we measure in a sample of algae to determine if the algae are lacking in one of these limiting nutrients.

2. Mass balance

Another important tool that biogeochemists use is a simple mass balance equation to describe the state of a system. The system could be a snake, a tree, a lake, or the entire globe. Using a mass balance approach we can determine whether the system is changing and how fast it is changing. The equation is:

NET CHANGE = INPUT + OUTPUT + INTERNAL CHANGE

In this equation the net change in the system from one time period to another is determined by what the inputs are, what the outputs are, and what the internal change in the system was. The example given in class is of the acidification of a lake, considering the inputs and outputs and internal change of acid in the lake.

3. Element cycling

Element cycling describes where and how fast elements move in a system. There are two general classes of systems that we can analyse, as mentioned above: closed and open systems.

A closed system refers to a system where the inputs and outputs are negligible compared to the internal changes. Examples of such systems would include a bottle, or our entire globe. There are two ways we can describe the cycling of materials within this closed system, either by looking at the rate of movement or at the pathways of movement.

1. Rate = number of cycles / time * as rate increases, productivity increases
2. Pathways-important because of different reactions that may occur

In an open system there are inputs and outputs as well as the internal cycling. Thus we can describe the rates of movement and the pathways, just as we did for the closed system, but we can also define a new concept called the residence time. The residence time indicates how long on average an element remains within the system before leaving the system.

1. Rate
2. Pathways
3. Residence time, Rt

Rt = total amount of matter / output rate of matter
(Note that the "units" in this calculation must cancel properly)

4.5. Controls on ecosystem function

Now that we have learned something about how ecosystems are put together and how materials and energy flow through ecosystems, we can better address the question of "what controls ecosystem function"? There are two dominant theories of the control of ecosystems. The first, called bottom-up control, states that it is the nutrient supply to the primary producers that ultimately controls how ecosystems function. If the nutrient supply is increased, the resulting increase in production of autotrophs is propagated through the food web and all of the other trophic levels will respond to the increased availability of food (energy and materials will cycle faster).

The second theory, called top-down control, states that predation and grazing by higher trophic levels on lower trophic levels ultimately controls ecosystem function. For example, if you have an increase in predators, that increase will result in fewer grazers, and that decrease in grazers will result in turn in more primary producers because fewer of them are being eaten by the grazers. Thus the control of population numbers and overall productivity "cascades" from the top levels of the food chain down to the bottom trophic levels.

So, which theory is correct? Well, as is often the case when there is a clear dichotomy to choose from, the answer lies somewhere in the middle. There is evidence from many ecosystem studies that BOTH controls are operating to some degree, but that NEITHER control is complete. For example, the "top-down" effect is often very strong at trophic levels near to the top predators, but the control weakens as you move further down the food chain. Similarly, the "bottom-up" effect of adding nutrients usually stimulates primary production, but the stimulation of secondary production further up the food chain is less strong or is absent.

Thus we find that both of these controls are operating in any system at any time, and we must understand the relative importance of each control in order to help us to predict how an ecosystem will behave or change under different circumstances, such as in the face of a changing climate.

4.6. The Geography of ecosystems

There are many different ecosystems: rain forests and tundra, coral reefs and ponds, grasslands and deserts. Climate differences from place to place largely determine the types of ecosystems we see. How terrestrial ecosystems appear to us is influenced mainly by the dominant vegetation.

The word "biome" is used to describe a major vegetation type such as tropical rain forest, grassland, tundra, etc., extending over a large geographic area (Figure 16). It is never used for aquatic systems, such as ponds or coral reefs. It always refers to a vegetation category that is dominant over a very large geographic scale, and so is somewhat broader than an ecosystem.

We can draw upon previous lectures to remember that temperature and rainfall patterns for a region are distinctive. Every place on earth gets the same total number of hours of sunlight each year, but not the same amount of heat. The sun's rays strike low latitudes directly but high latitudes obliquely. This uneven distribution of heat sets up not just temperature differences, but global wind and ocean currents that in turn have a great deal to do with where rainfall occurs. Add in the cooling effects of elevation and the effects of land masses on temperature and rainfall, and we get a complicated global pattern of climate.

A schematic view of the earth shows that complicated though climate may be, many aspects are predictable (Figure 17). High solar energy striking near the equator ensures nearly constant high temperatures and high rates of evaporation and plant transpiration. Warm air rises, cools, and sheds its moisture, creating just the conditions for a tropical rain forest. Contrast the stable temperature but varying rainfall of a site in Panama with the relatively constant precipitation but seasonally changing temperature of a site in New York State. Every location has a rainfall- temperature graph that is typical of a broader region (Wessells and Hopson, 1988).

We can draw upon plant physiology to know that certain plants are distinctive of certain climates, creating the vegetation appearance that we call biomes. Note how well the distribution of biomes plots on the distribution of climates (Figure 18). Note also that some climates are impossible, at least on our planet. High precipitation is not possible at low temperatures -- there is not enough solar energy to power the water cycle, and most water is frozen and thus biologically unavailable throughout the year. The high tundra is as much a desert as is the Sahara (Borman and Likens, 1970).

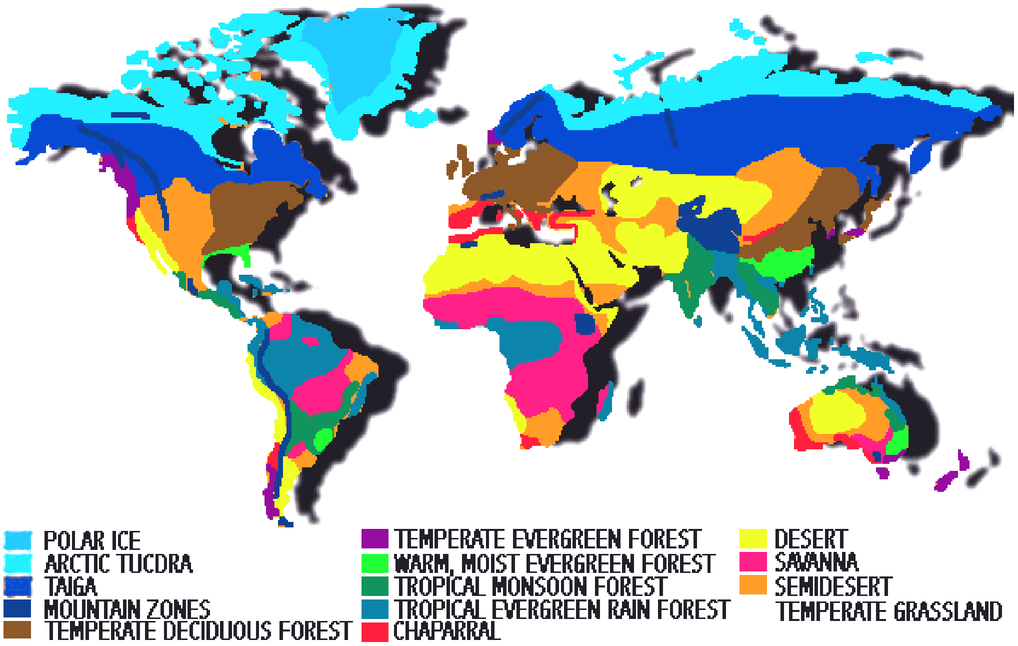

Fig. 16. The distribution of biomes.

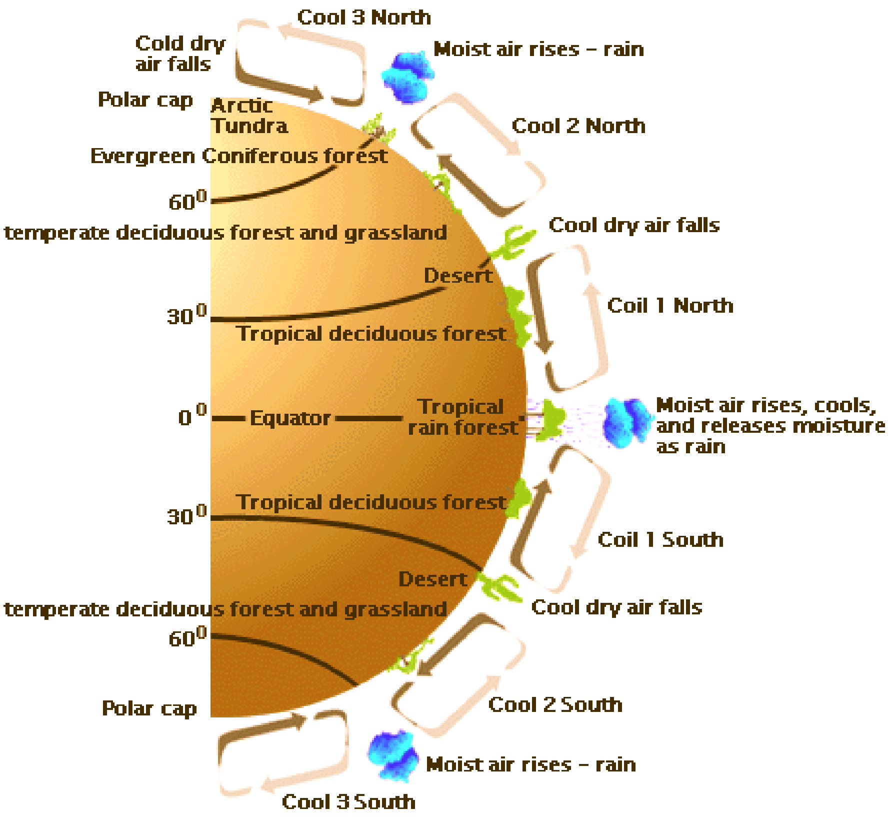

Fig. 17. Climate patterns affect biome distributions.

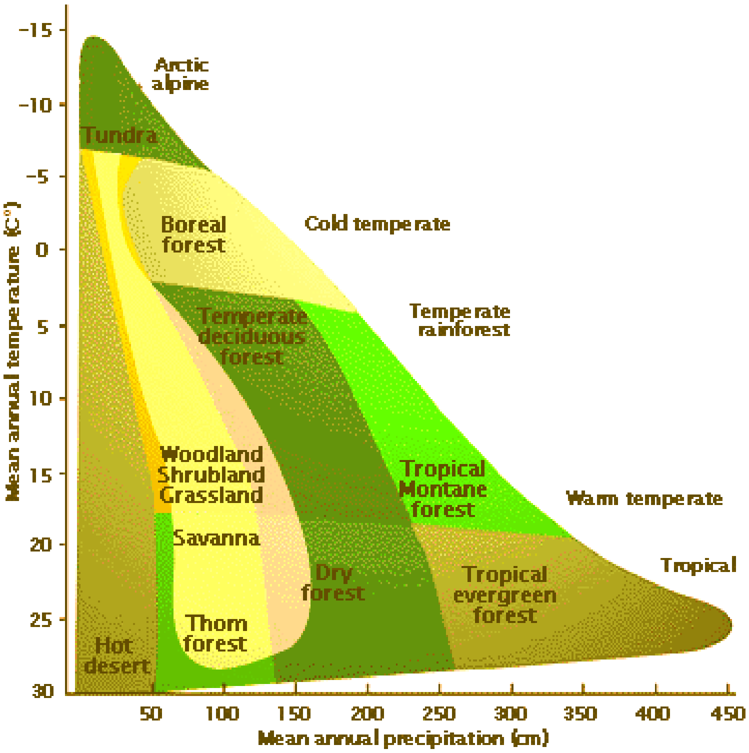

Fig. 18. The distribution of biomes related to temperature and precipitation.

4.7. Summary

- Ecosystems are made up of abiotic (non-living, and environmental) and biotic components and these basic components are important to nearly all types of ecosystems. Ecosystem Ecology looks at energy transformations and biogeochemical cycling within ecosystems.
- Energy is continually input into an ecosystem in the form of light energy, and some energy is lost with each transfer to a higher trophic level. Nutrients, on the other hand, are recycled within an ecosystem, and their supply normally limits biological activity. So, "energy flows, elements cycle".
- Energy is moved through an ecosystem via a food web, which is made up of interlocking food chains. Energy is first captured by photosynthesis (primary production). The amount of primary production determines the amount of energy available to higher trophic levels.
- The study of how chemical elements cycle through an ecosystem is termed biogeochemistry. A biogeochemical cycle can be expressed as a set of stores (pools) and transfers, and can be studied using the concepts of "stoichiometry", "mass balance", and "residence time".
- Ecosystem function is controlled mainly by two processes, "top-down" and "bottom-up" controls.
- A biome is a major vegetation type extending over a large area. Biome distributions are determined largely by temperature and precipitation patterns on the earth's surface.

5. Conclusion

The increased exploitation of renewable energy sources is central to any move towards sustainable development. However, casting renewable energy thus carries with it an inherent commitment to other basic tenets of sustainability, openness, democraticisations, etc. Due to increasing fossil fuel prices, the research in renewable energy technologies (RETs) utilisation has picked up a considerable momentum in the world. The present day energy arises has therefore resulted in the search for alternative energy resources in order to cope with the drastically changing energy picture of the world. The environmental sustainability of the current global energy systems is under serious question. A major transition away from fossil fuels to one based on energy efficiency and renewable energy is required. Alternatively energy sources can potentially help fulfill the acute energy demand and sustain economic growth in many regions of the world. The mitigation strategy of the country should be based primarily ongoing governmental programmes, which have originally been launched for other purposes, but may contribute to a relevant reduction of greenhouse gas emissions (energy-saving and afforestation programmes). Throughout the study several issues relating to renewable energies, environment and sustainable development are examined from both current and future perspectives. The exploitation of the energetic potential (solar and wind) for the production of electricity proves to be an adequate solution in isolated regions where the extension of the grid network would be a financial constraint.

The provision of good indoor environmental quality while achieving energy and cost efficient operation of the heating, ventilating and air-conditioning (HVAC) plants in buildings represents a multi variant problem. The comfort of building occupants is dependent on many environmental parameters including air speed, temperature, relative humidity and quality in addition to lighting and noise. The overall objective is to provide a high level of building performance (BP), which can be defined as indoor environmental quality (IEQ), energy efficiency (EE) and cost efficiency (CE).

- Indoor environmental quality is the perceived condition of comfort that building occupants experience due to the physical and psychological conditions to which they are exposed by their surroundings. The main physical parameters affecting IEQ are air speed, temperature, relative humidity and quality.
- Energy efficiency is related to the provision of the desired environmental conditions while consuming the minimal quantity of energy.
- Cost efficiency is the financial expenditure on energy relative to the level of environmental comfort and productivity that the building occupants attained. The overall cost efficiency can be improved by improving the indoor environmental quality and the energy efficiency of a building.

Closing remarks

In this review, we have focused our attention solely on ecosystem engineers and their engineering activities. This focus was necessary because ecosystem engineering is an important ecological factor. However, it is important to remember that most ecosystem engineers influence the distribution and abundance of other organisms in many ways, not just by engineering. A good example of this can be seen with European wood ants (Formica rufa species group) and the many ways they affect other animal species. When wood ants build their nest mounds (allogenic engineering), they create new microhabitats which greatly increase the abundance of litter-dwelling earthworms (Laakso and Setala, 1997). When these same ants attack songbirds in trees near their nesting mounds, they are using territorial defense behaviour (interference competition) to drive birds' away (Haemig, 1996, 1999). Finally, when wood ants prey on other invertebrates, causing a decrease in arthropod populations within the wood ant territory, a trophic interaction is occurring (Skinner and Whittaker, 1981; Haemig, 1994). Thus, wood ants alter the abundance and distribution of many different animal species using a variety of mechanisms, only one of which is "ecosystem engineering".

References

Alkon, P.U., 1999. Microhabitat to landscape impacts: crested porcupine digs in the Negev desert highlands. J. Arid. Environ., 41, 183-202.

Boeken, B., Shachak, M., Gutterman, Y., Brand, S., 1995. Patchiness and disturbance: plant community responses to porcupine diggings in the central Negev. Ecography, 18, 410-422.

Borman, F.H., Likens, G.E., 1970. The nutrient cycles of an ecosystem. Sci. Am., October, 92-101.

Casas-Crivillé, A., Valera, F., 2005. The European bee-eater (Merops apiaster) as an ecosystem engineer in arid environments. J. Arid. Environ., 60, 227-238.

Charles-Dominique, P., Atramentowicz, M., Charles-Dominique, M., Gérard, H., Hladik, A., Hladik, C.M., Prévost, F., 1981. Les mammifères frugivores arboricoles nocturnes d'une forêt guyanaise: interrelations plantes-animaux. Rev Ecol (Terre Vie), 35, 341-435.

Charles-Dominique, P., 1971. Eco-éthologie des Prosimiens du Gabon. Biol. Gabonica., 7, 121-228.

Gutiérrez, J.L., Jones, C.G., Strayer, D.L., Iribarne, O.O., 2003. Mollusks as ecosystem engineers: the role of shell production in aquatic habitats. Oikos, 101, 79-90.

Haemig, P.D., 1996. Interference from ants alters foraging ecology of great tits. Behav. Ecol. Socio-biol., 38, 25-29.

Haemig, P.D., 1994. Effects of ants on the foraging of birds in spruce trees. Oecologia, 97, 35-40.

Haemig, P.D., 1999. Predation risk alters interactions among species: competition and facilitation between ants and nesting birds in a boreal forest. Ecol. Letter., 2, 178-184.

Jones, C.G., Lawton, J.H., Shachak, M., 1997. Positive and negative effects of organisms as physical ecosystem engineers. Ecol., 78, 1946-1957.

Jones, C.G., Lawton, J.H., Shachak, M., 1994. Organisms as ecosystem engineers. Oikos, 69, 373-386.

Laakso, J., Setala, H., 1997. Nest mounds of red wood ants (Formica aquilonia): hot spots for litter-dwelling earthworms. Oecologia, 111, 565-569.

Lill, J.T., Marquis, R.J., 2003. Ecosystem engineering by caterpillars increases insect herbivore diversity on white oak. Ecol., 84, 682-690.

Nieder, J., Prosperi, J., Michaloud, G., 2001. Epiphytes and their contribution to canopy diversity. Plant. Ecol., 153, 51-63.

Peters, W., 1992. A colour atlas of arthropods in clinical medicine.Wolfe Publishing, London.

Reichman, O.J., Seabloom, E.W., 2002a. The role of pocket gophers as subterranean ecosystem engineers. Trends in Ecology and Evolution, 17, 44-49.

Reichman, O.J., Seabloom, E.W., 2002b. Ecosystem engineering: a trivialised concept? Response from Reichman and Seabloom.Trends in Ecology and Evolution, 17, 308.

Sillett, S.C., Van Pelt, R., 2000. A redwood tree whose crown is a forest canopy. Northwest Science, 74, 34-43.

Skinner, G.J., Whittaker, J.B., 1981. An experimental investigation of inter-relationships between the wood-ant (Formica rufa) and some tree-canopy herbivoures. J. Anim. Ecol., 50, 313-326.

Wessells, N.K., Hopson, J.L., 1988. Biology. New York: Random House. Ch. 44.

Wilby, A., 2002. Ecosystem engineering: a trivialised concept? Trends in Ecology and Evolution, 17, 307.

Wilby, A., Shachak, M., Boeken, B., 2001. Integration of ecosystem engineering and trophic effects of herbivores. Oikos, 92, 436-444.

Wright, J.P., Jones, C.G., Flecker, A.S., 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia, 132, 96-101.

Zotz, G., Vollrath, B., 2003. The epiphyte vegetation of the palm Socratea exorrhiza - correlations with tree size, tree age and bryophyte cover. J. Trop. Ecol., 19, 81-90.

Other readings

Abdeen, M.O., 2008. Green energies and environment. Renew. Sustain. Energ. Rev., 12, 1789-1821.

Abdeen, M.O., 2009. Principle of low energy building design: Heating, ventilation and air- conditioning, Cooling India: India's Premier Magazine on the Cooling Industry, Mumbai, India., 5(4), 26-46, 2009.

Abdeen, M.O., 2012. Clean and green energy technologies: Sustain. Dev. Environ. Sky. J. Agr. Res., 1(2), 28 – 50.

ASHRAE, 2003. Energy efficient design of new building except new low-rise residential buildings. BSRIASHRAE proposed standards 90-2P-1993, alternative GA. American Society of Heating, Refrigerating, and Air Conditioning Engineers Inc., USA.

ASHRAE, 2005. Commercial/Institutional Ground Source Heat Pump Engineering Manual. American Society of heating, Refrigeration and Air-conditioning Engineers, Inc. Atlanta, GA: USA.

Barabaro, S., Coppolino, S., Leone, C., Sinagra, E., 1978. Global solar radiation in Italy. Sol. Energ., 20, 431-38.

Baruah, D., 1995. Utilisation pattern of human and fuel energy in the plantation. J. Agr. Soil. Sci., 8(2), 189-92.

Bendewald, M., Zhai, Z.J., 2013. Using carrying capacity as a base line for building sustainability assessment. Habitat. Int., 37, 1-30.

Bos, E., My, T., Vu, E., Bulatao, R., 1994. World population projection: 1994-95. Baltimore and London: World Bank by the John Hopkins University Press.

CAEEDAC, 2000. A descriptive analysis of energy consumption in agriculture and food sector in Canada. Final Report, February.

Cantrell, J., Wepfer, W., 1984. Shallow ponds for dissipation of building heat: a case study. ASHRAE Transactions, 90(1), 239-246.

D'Apote, S.L., 1998. IEA biomass energy analysis and projections. In: Proceedings of Biomass Energy Conference: Data, analysis and Trends, Paris: OECD, 23-24 March.

David, J.M., 2000. Developing hydrogen and fuel cell products. Energ. World., 303, 16-17.

Duchin, F., 1995. Global scenarios about lifestyle and technology, the sustainable future of the global system. Tokyo: United Nations University.

Duffie, J.A., Beckman, W.A., 1980. Solar Engineering of Thermal Processes. New York: J. Wiley and Sons.

Dutt, B., 1982. Comparative efficiency of energy use in rice production. Energ., 6, 25.

EWEA, 2003. Wind force, 12. Brussels.

Gerald, S., 2012. Why we disagree about climate change: A different viewpoint. Energ. Environ., 23(8), 76-95.

Givoni, B., 1998. Climate consideration in building and urban design. New York: Van Nostrand Reinhold.

Glaas, E., Juhola, S., 2013. New levels of climate adaptation policy: Analysing the institutional interplay in the Baltic Sea Region. Sustainability, 1, 56-122.

Hall, O., Scrase, J., 1998. Will biomass be the environmentally friendly fuel of the future? Biomass and Bioenergy, 15, 357-67.

IHA, 2003. World Atlas and Industry Guide. The International Journal Hydropower and Dams, United Kingdom.

John, A., James, S., 1989. The power of place: bringing together geographical and sociological imaginations.

Kammerud, R., Ceballos, E., Curtis, B., Place, W., Anderson, B., 1984. Ventilation cooling of residential buildings. ASHRAE Trans, 90 Part 1B.

Kavanaugh, S., Rafferty, K., 1997. Ground source heat pumps. Design of geothermal systems for commercial and institutional buildings. American Society of heating, Refrigeration and Air-conditioning Engineers, Inc. Atlanta, GA: USA.

Lin, K., Chang, T.C., 2013. Everyday crises: Marginal society livelihood vulnerability and adaptability to hazards. Progress in Development Studies, 13(1), 45-78.

Morrow, K., 2012. Rio+20, the green economy and re-orienting sustainable development. Environ. Law. Rev., 14 (4), 15-23.

Njeru, J., 2013. Donor-driven neoliberal reform processes and urban environmental change in Kenya: The case of Karura Forest in Nairobi. Progress in Development Studies, 13(1), 17-25.

Odeku, K.O., Maveneka, A., Konanani, R.H., 2013. Consequences of country’s withdrawal from climate change agreements: Implications for carbon emissions reduction. J. Human. Ecol., 41(1), 17-24.

OECD/IEA, 2004. Renewables for power generation: status and prospect. UK.

Okkan, P., 1993. Reducing CO_2 emissions-How do heat pumps compete with other options? IEA Heat Pump Centre Newsletter, 11(3), 24-26.

Pernille, M., 2004. Feature: Danish lessons on district heating. Energ. Resour. Sustain. Manag. Environ., March/April, 16-17.

Raphael, A.T., 2012. Energy and climate change: Critical reflection on the African Continent; Is There an Ideal REDD+ Programme? An Analysis of Journal Sustainable Development in Africa, 14(6), 25-36.

Rees, W.E., 1999. The built environment and the ecosphere: a global perspective. Build. Res. Inform., 27(4), 206-20.

Roriz, L., 2001. Determining the potential energy and environmental effects reduction of air conditioning systems. Commission of the European Communities DG TREN, 45-80.

Singh, J., 2000. On farm energy use pattern in different cropping systems in Haryana, India. Germany: International Institute of Management-University of Flensburg, Sustainable Energy Systems and Management, Master of Science.

Sitarz, D., 1992. Agenda 21: The earth summit strategy to save our planet. Boulder, CO: Earth Press.

Sivkov, S.I., 1964. On the computation of the possible and relative duration of sunshine. Trans. Main. Geoph. Obs., 160.

Sivkov, S.I., 1964. To the methods of computing possible radiation in Italy. Trans. Main Geophys. Obs., 160.

Steele, J., 1997. Sustainable architecture: principles, paradigms, and case studies. New York: McGraw-Hill Inc.

Strauss, J., 2013. Does housing drive state-level job growth? Building permits andconsumer expectations forecast a state’s economic activity. J. Urban. econ., 73, 65-87.

Szokolay, S., 1990. Design and research issues: passive control in the tropic. Proceedings First World Renewable Ener. Congress, 2337-2344, Reading: UK.

Thakur, C., Mistra, B., 1993. Energy requirements and energy gaps for production of major crops in India. Agricultural Situation of India, 48, 665-89.

The United Nations Framework Convention on Climate Change (UNFCCC), 2009. The draft of the Copenhagen climate change treaty, 3-181.

Tukahirwa, J.T., 2013. Comparing urban sanitation and solid waste management in East African metropolises: The role of civil society organisations. Cities, 30, 45-76.

United Nations (UN), 2003. World urbanisation project: the 2002 revision. New York: The United Nations Population Division.

Valkila, N., Saari, A., 2012. Perceptions held by finnish energy sector experts regarding public attitudes to energy Issue. J. Sustain. Dev., 5(11), 23-45.

Vargas-Parra, M.V., 2013. Applying exergy analysis to rainwater harvesting systems to assess resource efficiency. Resour. Conserv. Recycl., 72, 35-65.

Wu, J., Boggess, W., 1999. The optimal allocation of conservation funds. J. Environ. Econ. Manag., 38.

Yaldiz, O., Ozturk, H., Zeren, Y., 1993. Energy usage in production of field crops in Turkey. In: 5th International Congress on Mechanisation and Energy Use in Agriculture. Turkey: Kusadasi, 11-14 October.

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