

**GLOBAL CHANGES** and

THE ROLE OF ORGANISMS AS

# **ECOSYSTEM ENGINEERS**

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BEN GURION UNIVERSITY  
ISRAEL**

# IN DRYLANDS:

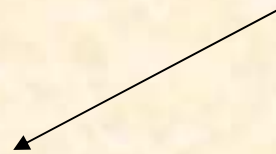
**WOODY VEGETATION**

**CYANOBACTERIA**



**BIOMASS PATCH FORMATION**

**SOIL CRUST FORMATION**



**BIOTIC INDUCED LANDSCAPE MOSAIC**

# **BIOTIC INDUCED LANDSCAPE MOSAIC**

**IS GENERATED BY  
ORGANISMS AS ECOSYSTEM ENGINEERS(EE)  
(Jones, Lawton and Shachak: Oikos 1994)**

**EE MODULATE THE LANDSCAPE STRUCTURE  
AND FUNCTION  
AS A PART OF  
THE GENERAL PROCESS OF**

**ENVIRONMENTAL IMPACT BY ORGANISMS**

# ENVIRONMENTAL IMPACT OF ORGANISMS

**ECOSYSTEM FUNCTION**



**BIODIVERSITY**



**ENVIRONMENTAL IMPACT**

*Entities  
affected*

organisms

Energy &  
nutrients

patches

*Level of  
organization*

Population &  
community

ecosystem

landscape

*Mechanisms*

Competition &  
predation

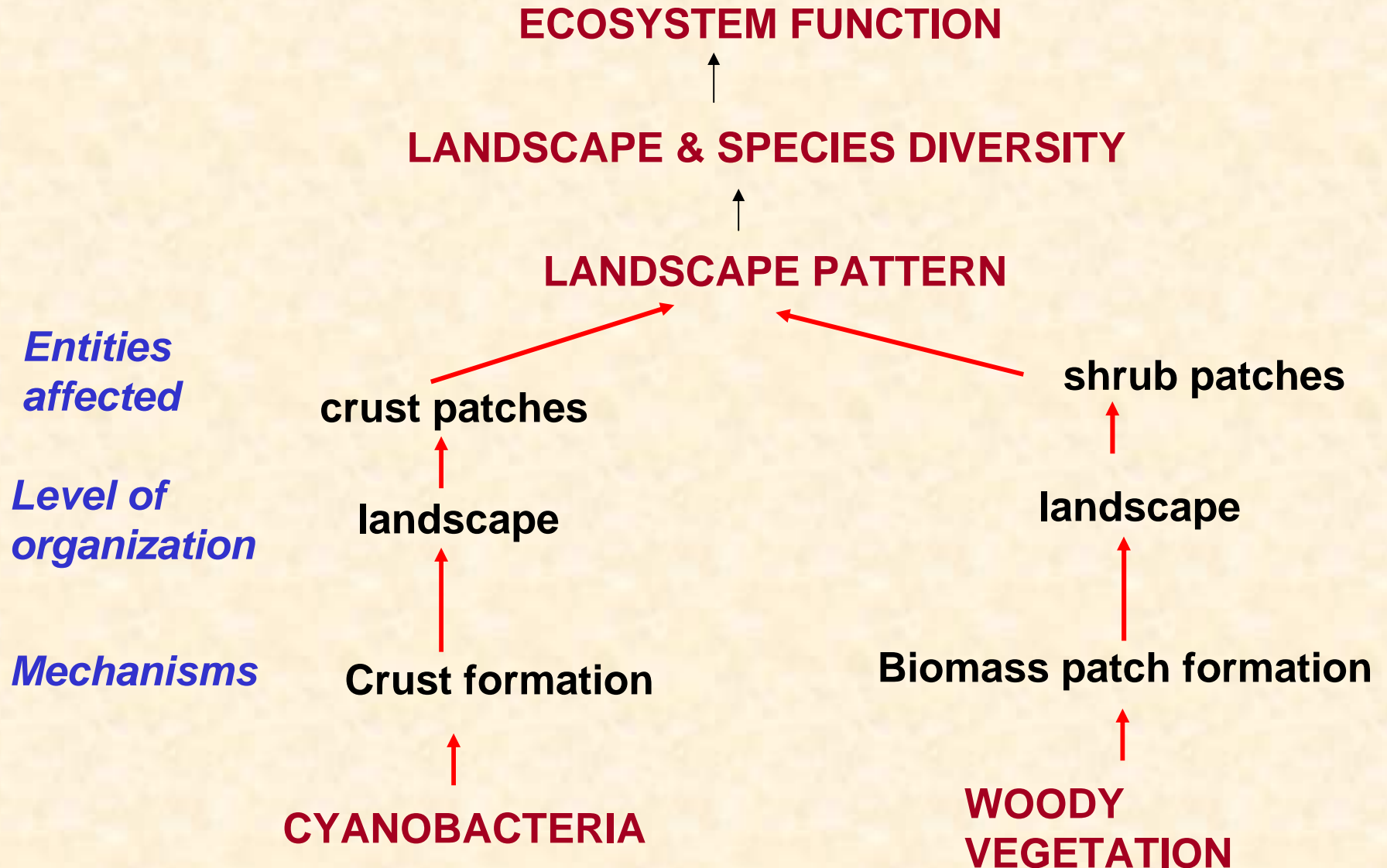
energy flow &  
nutrient cycling

Patch formation

**ORGANISMS**



# LANDSCAPE MODULATION IN DRYLANDS



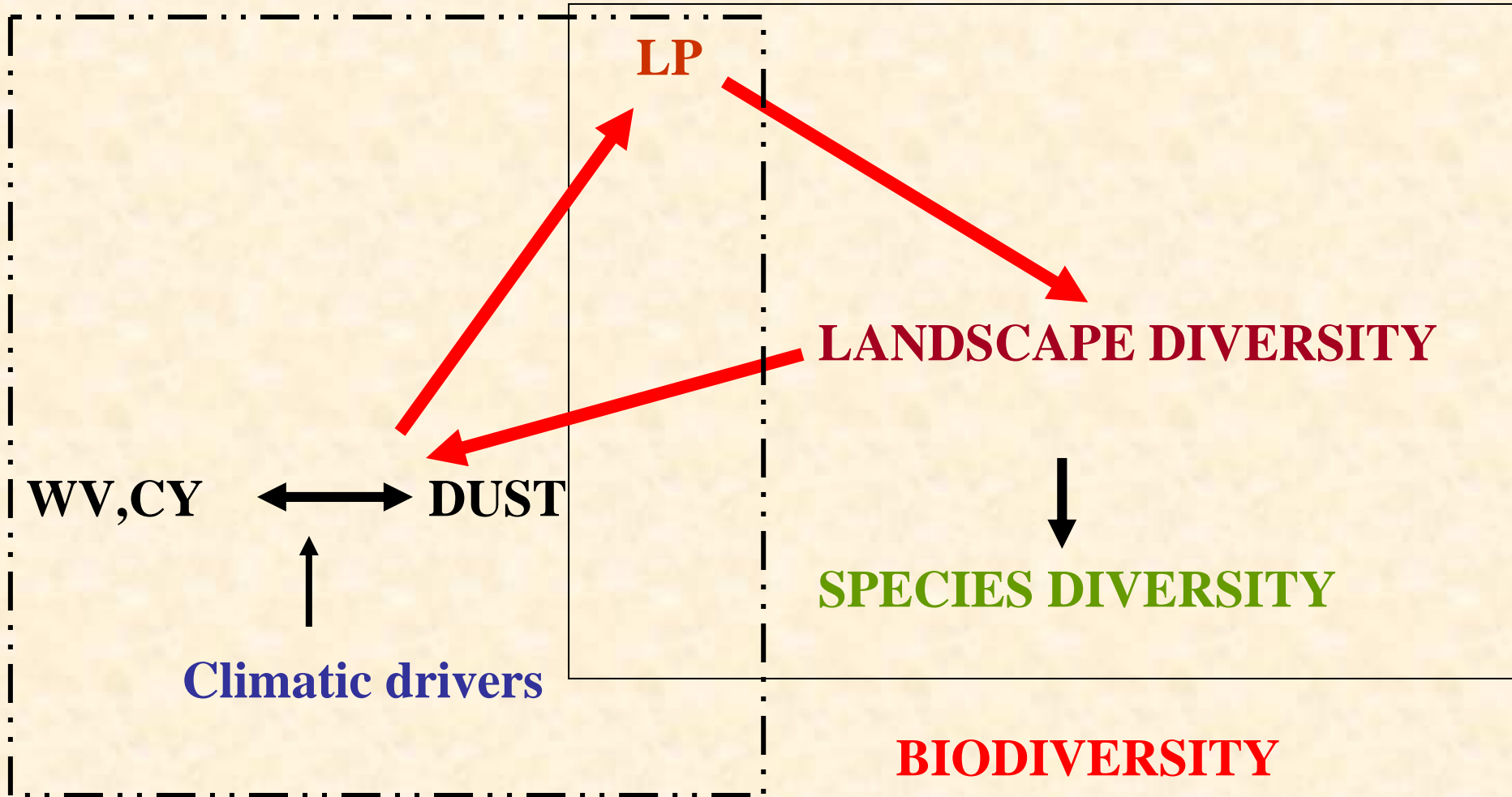
**LANDSCAPE MODULATOR (LM)- DEFINITION:**

**AN ECOSYSTEM ENGINEER THAT CREATES**

**A LANDSCAPE MOSAIC**

**BY THE PROCESS OF PATCH FORMATION**

# LANDSCAPE PATTERN(LP) AND BIODIVERSITY



**PATTERN FORMATION**

**BIODIVERSITY**

(Shachak et al 2005:  
Biodiversity in Drylands)



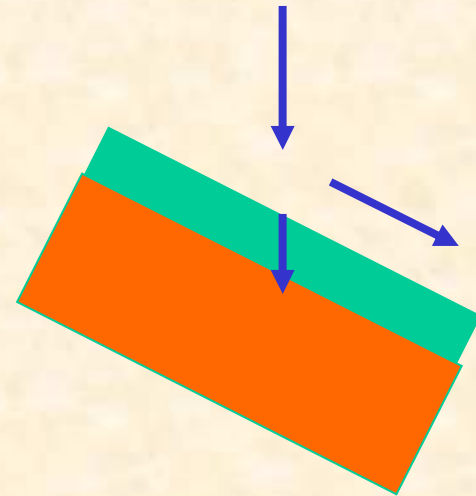
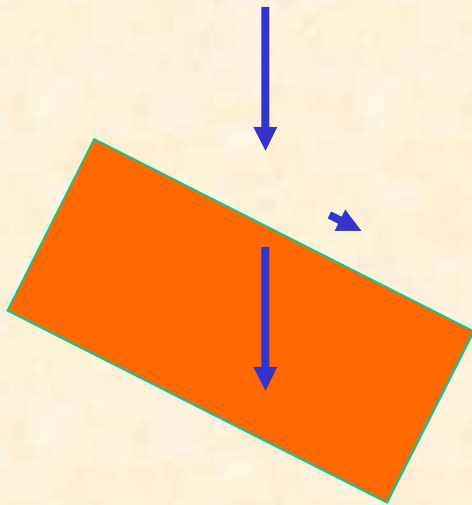
# SHRUB-CRUST SYSTEM

200mm rainfall



# **CYANOBACTERIA**

## **AS ECOSYSTEM ENGINEERS**

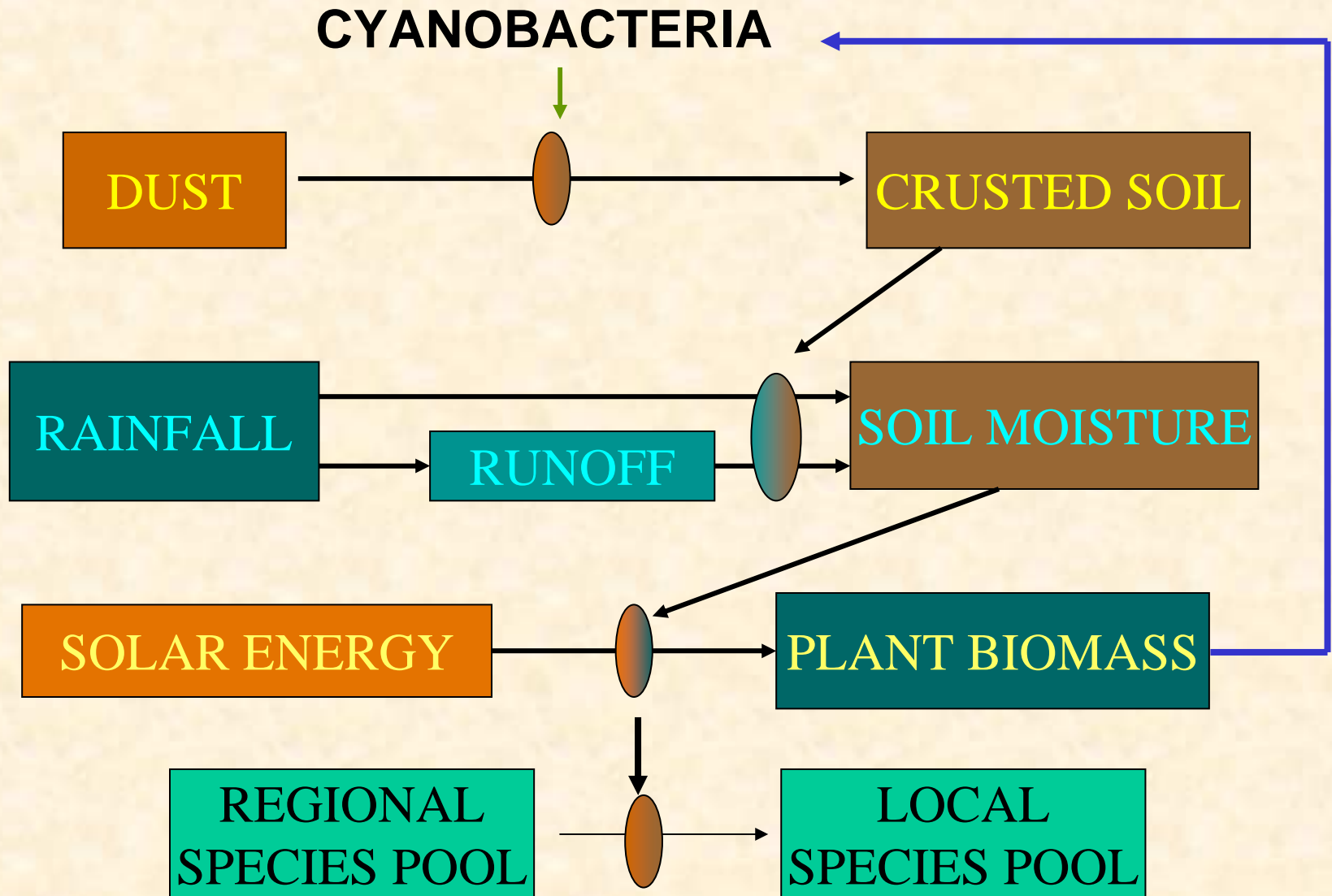


**HIGH WATER LEAKAGE**

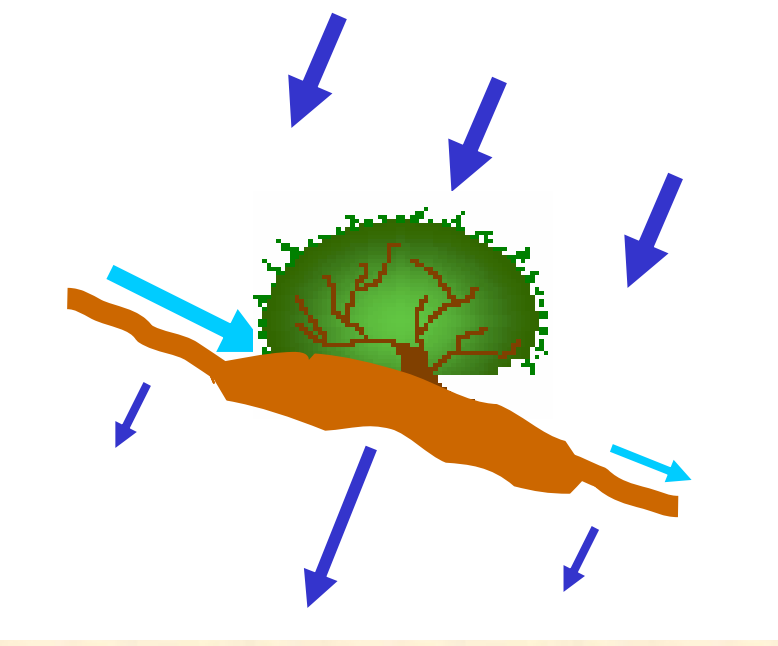
**LOW PRODUCTIVITY**

**LOW BIODIVERSITY**

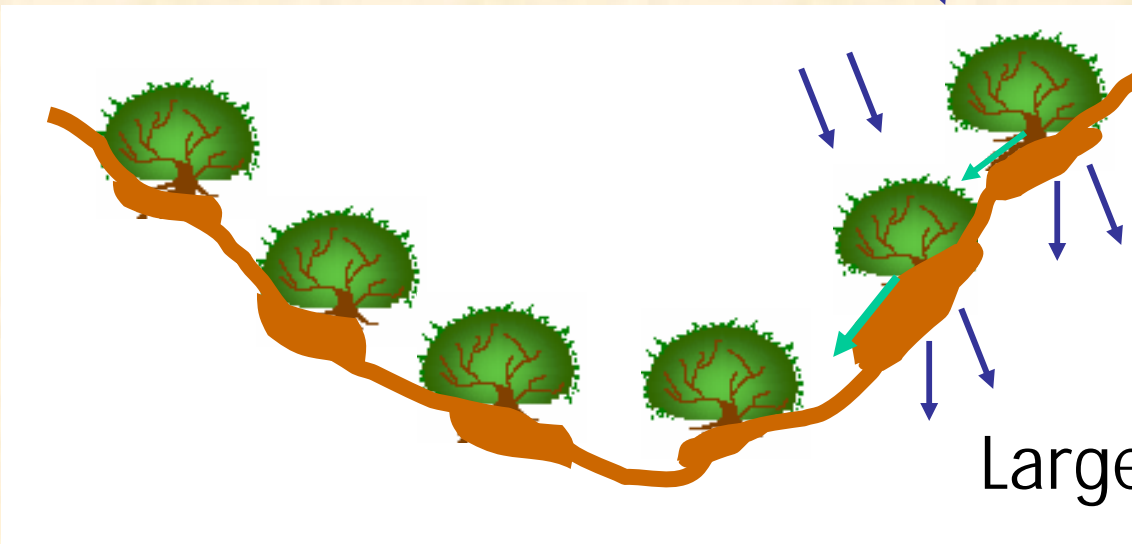
# CYANOBACTERIA AS AN ECOSYSTEM ENGINEER



# **SHRUBS** AS **ECOSYSTEM ENGINEERS**



Small scale

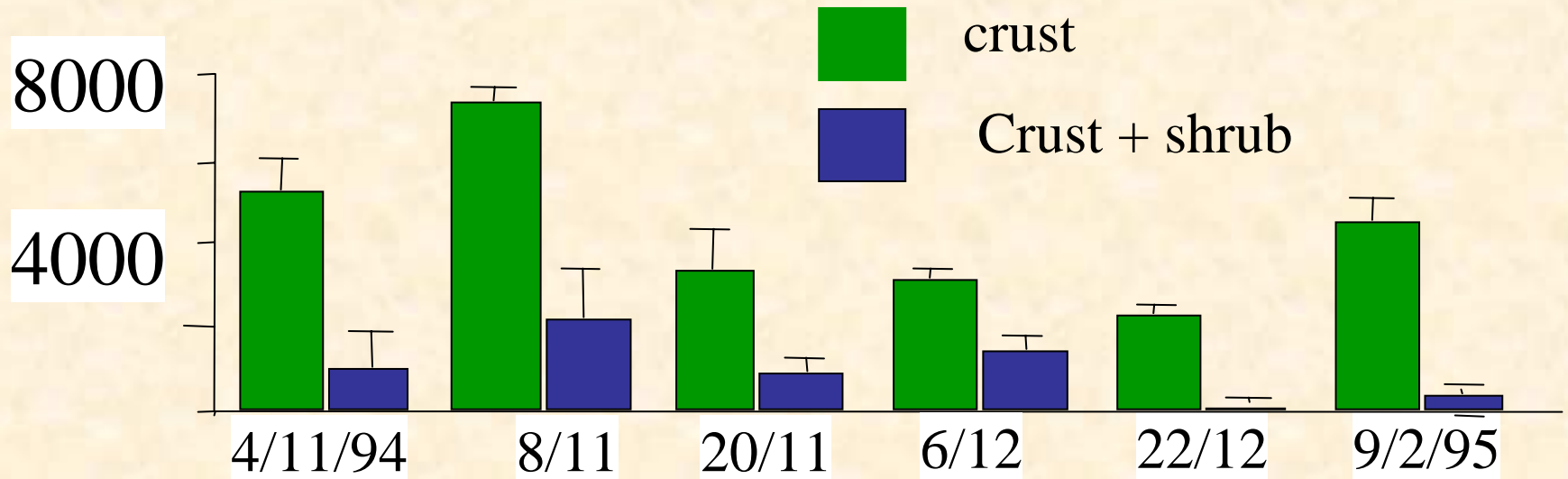


Large scale

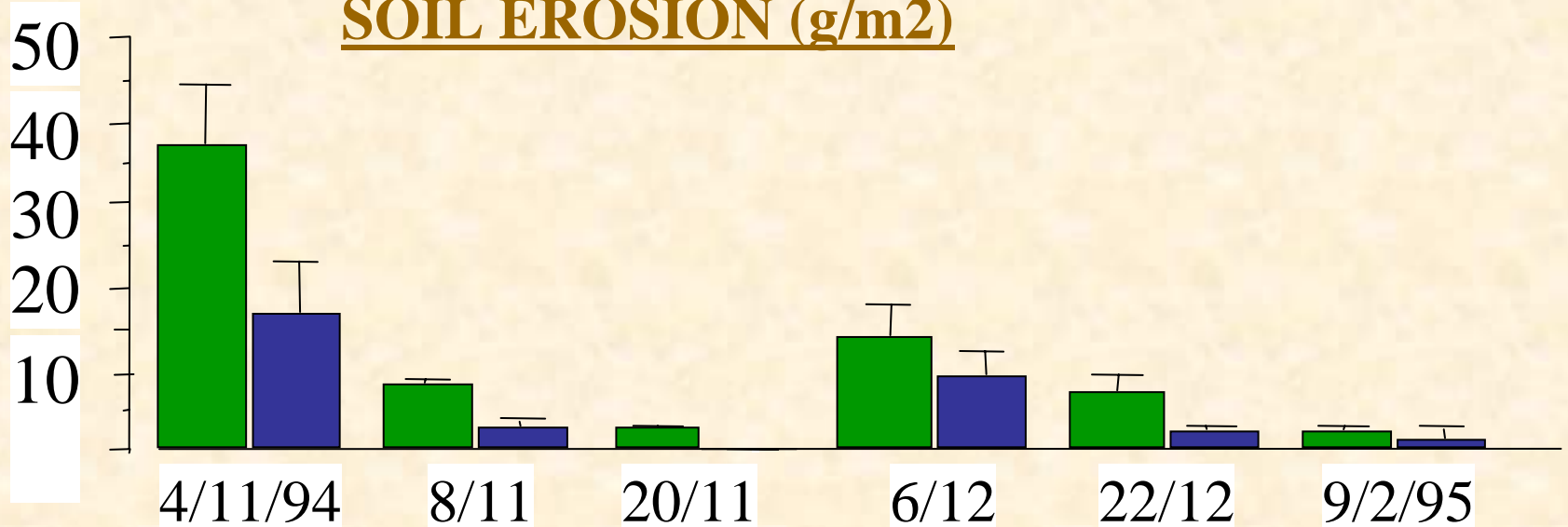
- LOW WATER LEAKAGE**
- HIGH PRODUCTIVITY**
- HIGH BIODIVERSITY**



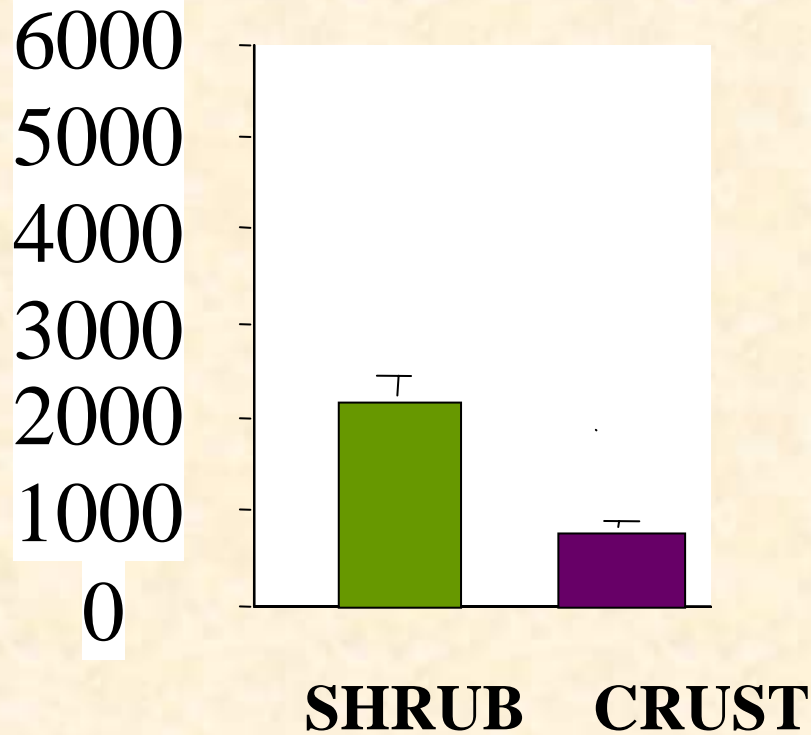
## WATER LOSS (ml/m<sup>2</sup>)



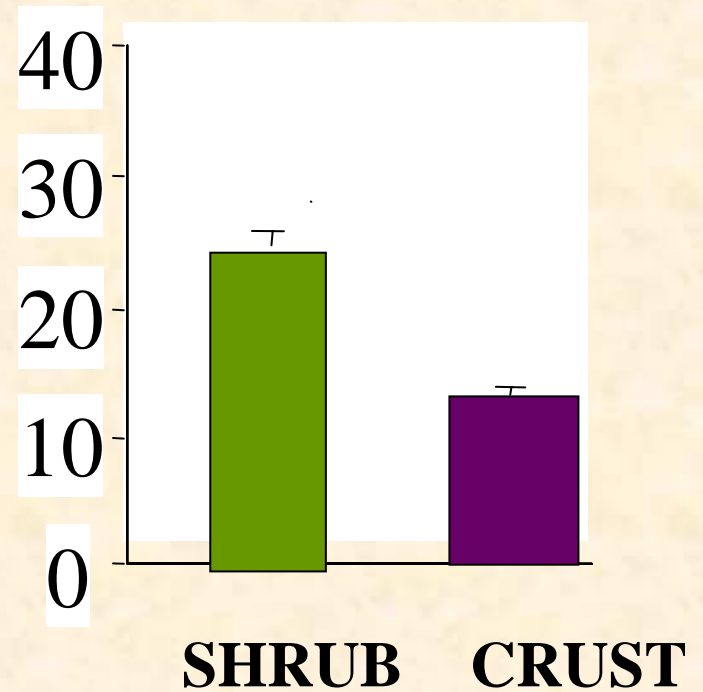
## SOIL EROSION (g/m<sup>2</sup>)



## PLANTS/m<sup>2</sup>

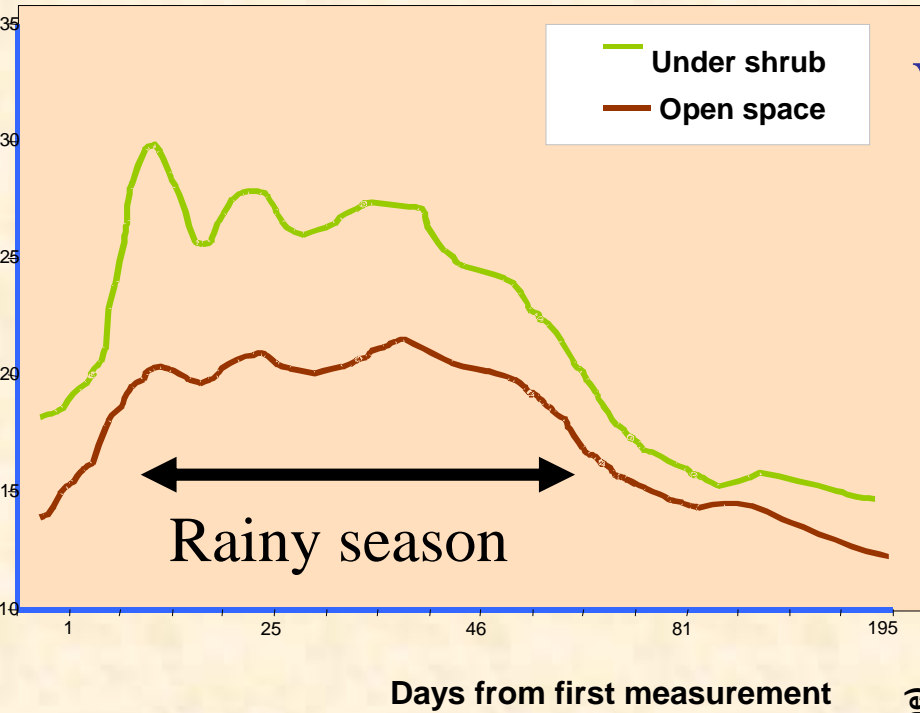


## SPECIES/PATCH



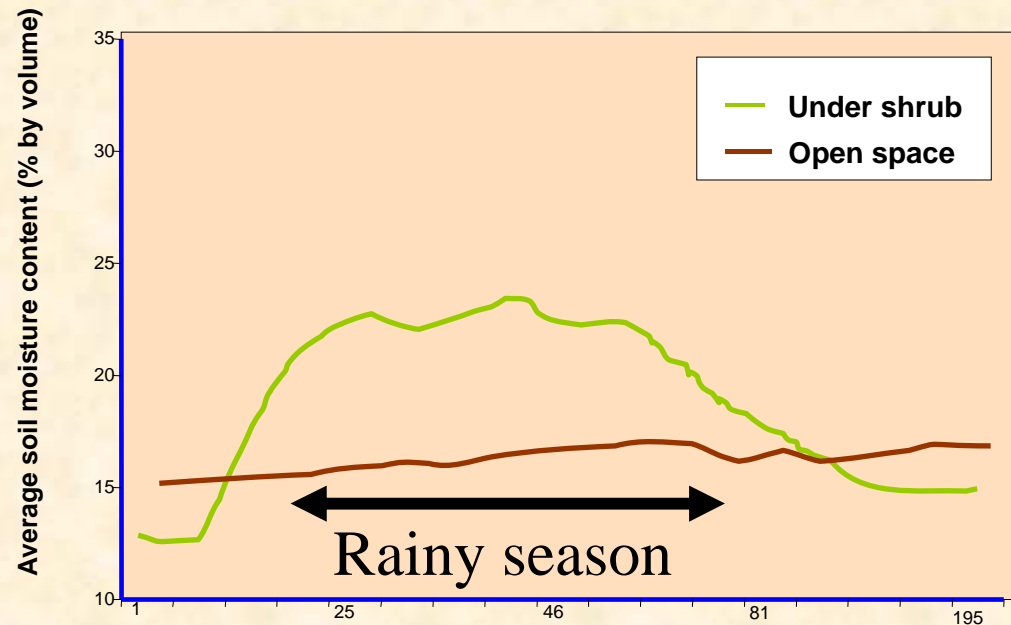
Boeken and Shachak 1994

0-80 cm

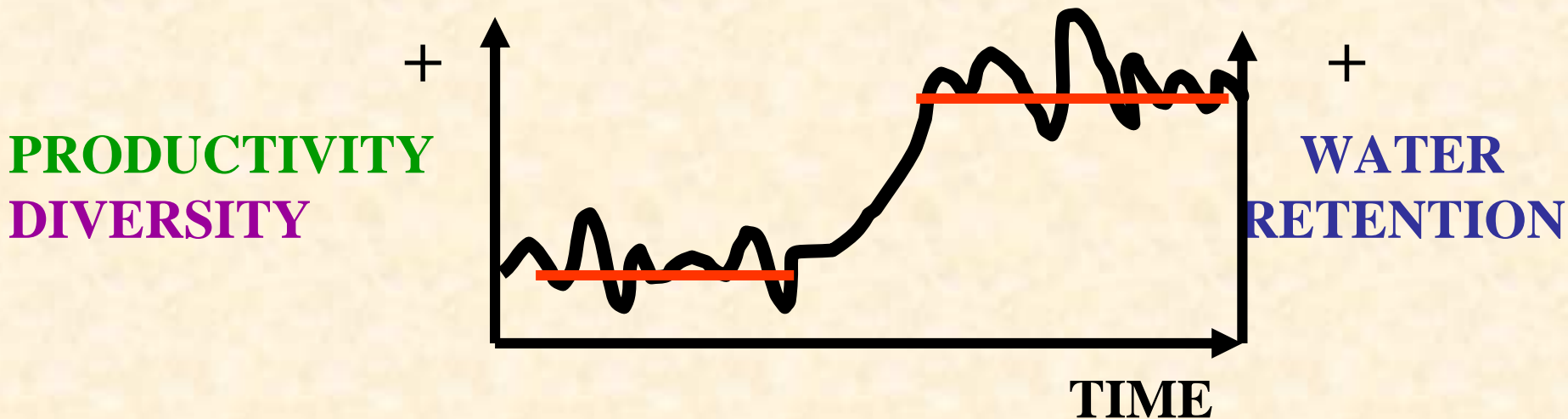
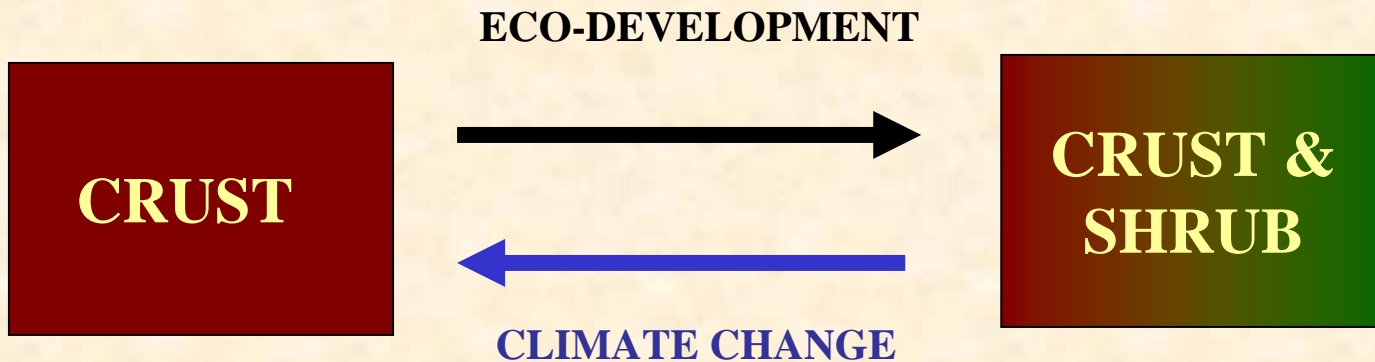


# WATER CONSERVATION BY SHRUB

80-160 cm



# ECOSYSTEM ENGINEERS & ECOSYSTEM STATES



# ODUM'S ECOSYSTEM DEVELOPMENT MODEL

## COMMUNITY STRUCTURE:

Species diversity-*Increases*

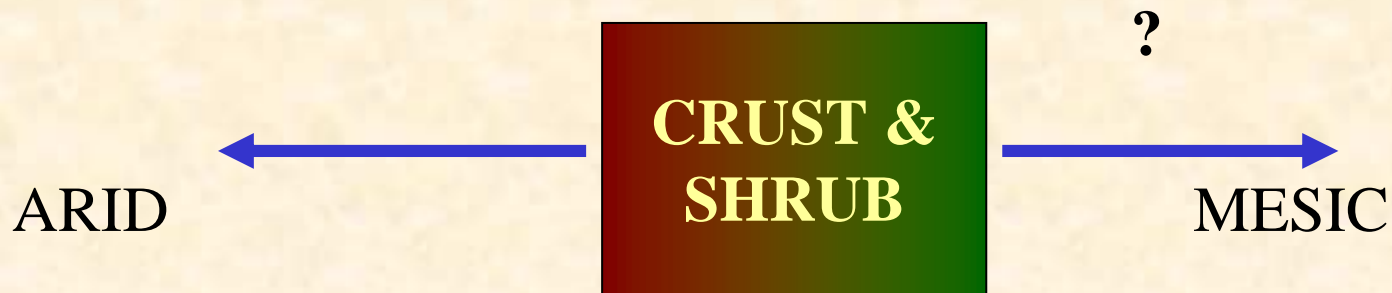
## ENERGY FLOW:

Gross production-*Increases*

## BIOGEOCHEMICAL CYCLES:

Storage of elements- *Increases*

# CLIMATE CHANGE AND CRUST & SHRUB STATE



INSIGHT FROM **MATHEMATICAL MODELLING**

# THE MODEL STRUCTURE

**THREE DYNAMIC VARIABLES:**

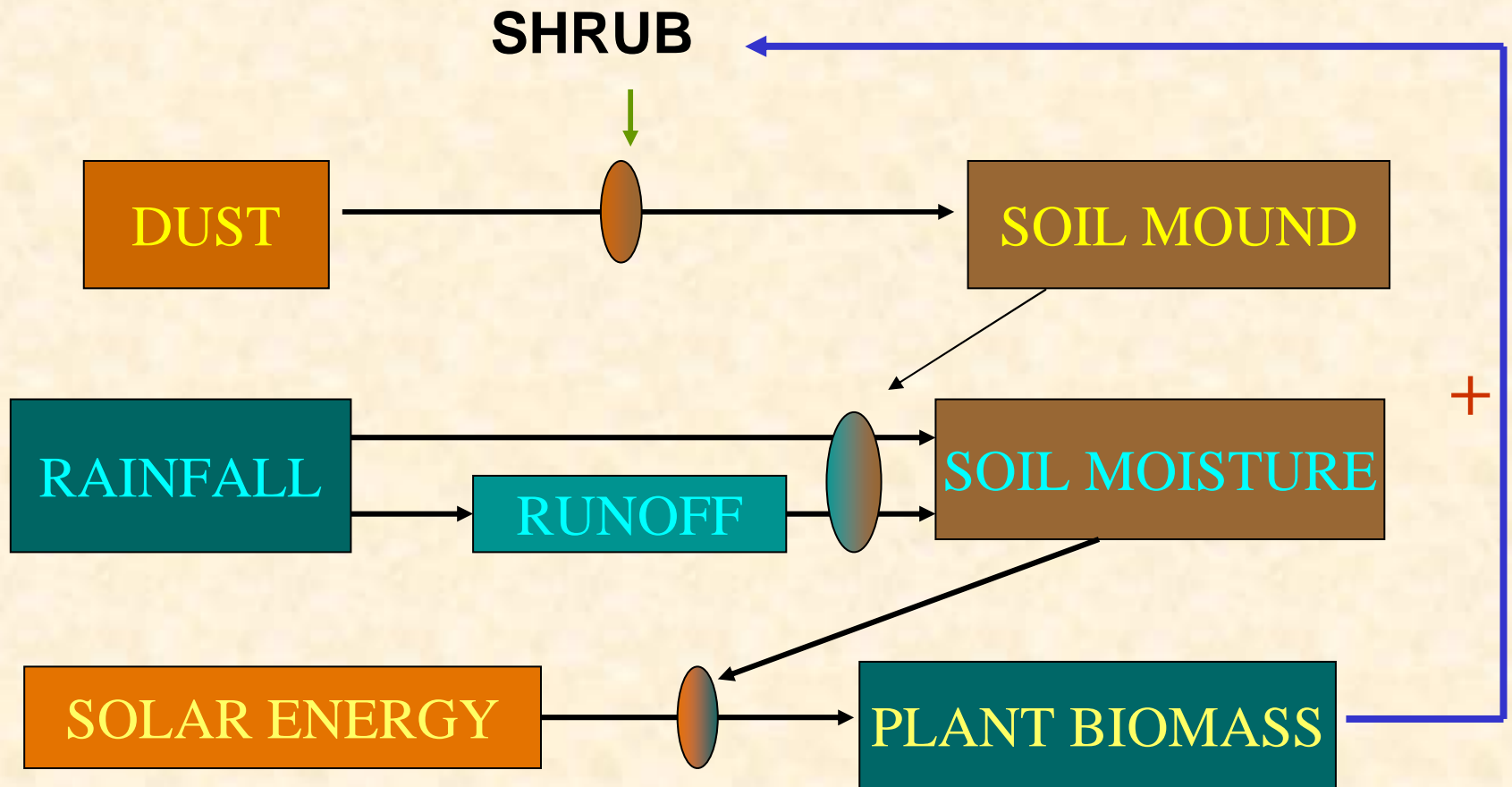
**(A) PLANT BIOMASS**

**(B) SOIL WATER CONTENT,**

**(C) SURFACE RUNOFF WATER,**

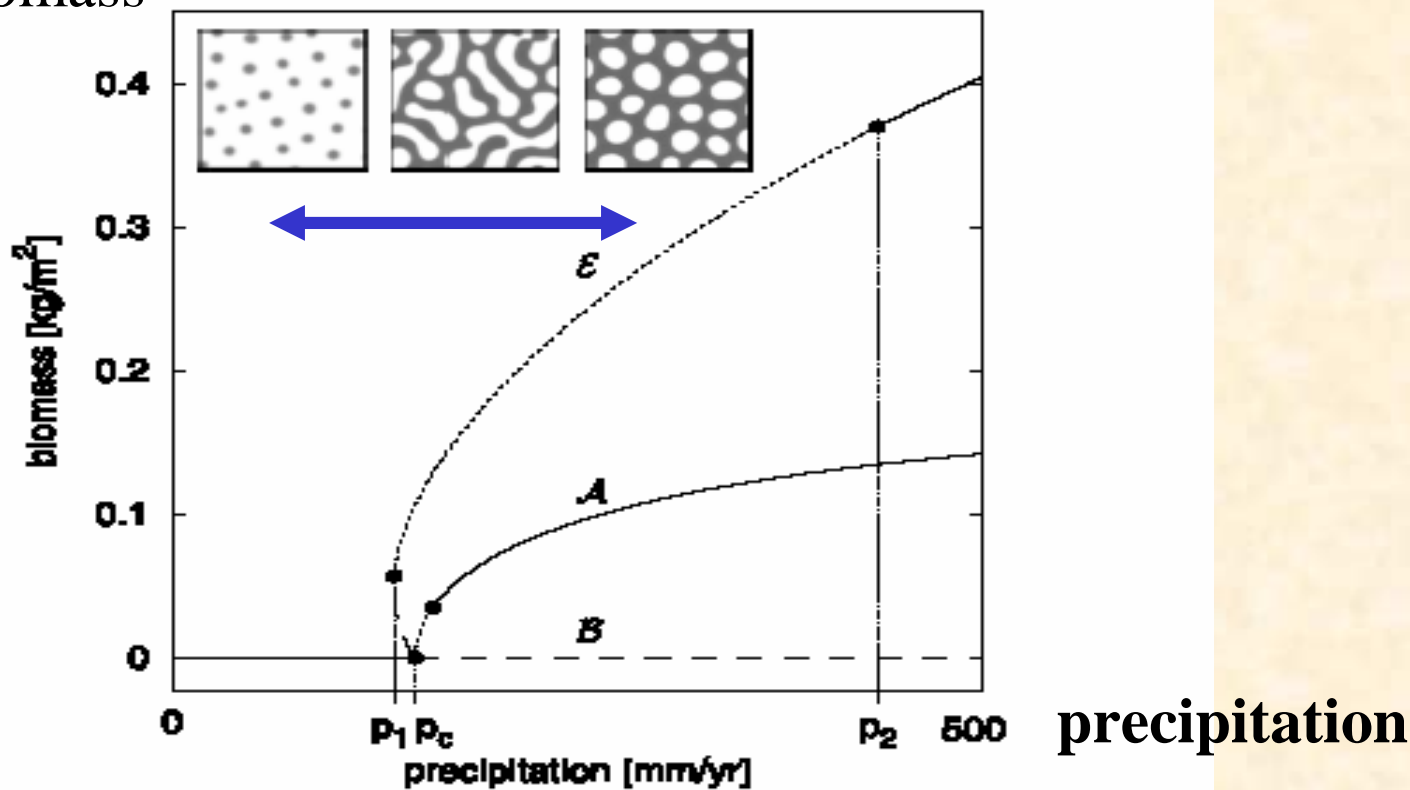
**A POSITIVE FEEDBACK  
BETWEEN BIOMASS AND WATER.**

# Graphical representation of the model



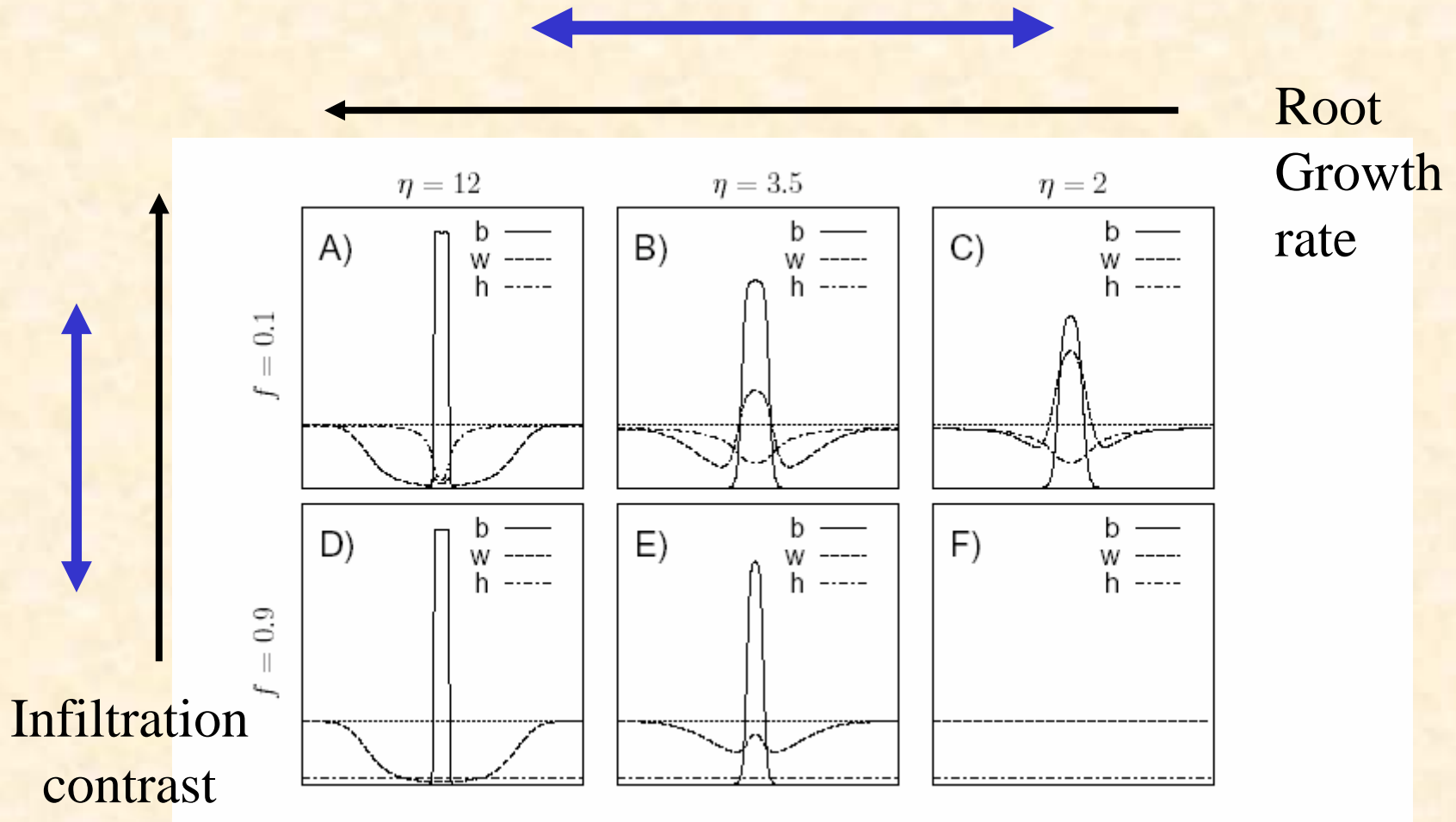
# CLIMATE CHANGE & BIOTIC INDUCED LANDSCAPE MOSAIC

biomass



Gilad et al 2004

# CLIMATE CHANGE & HYDRO-ENGINEERING

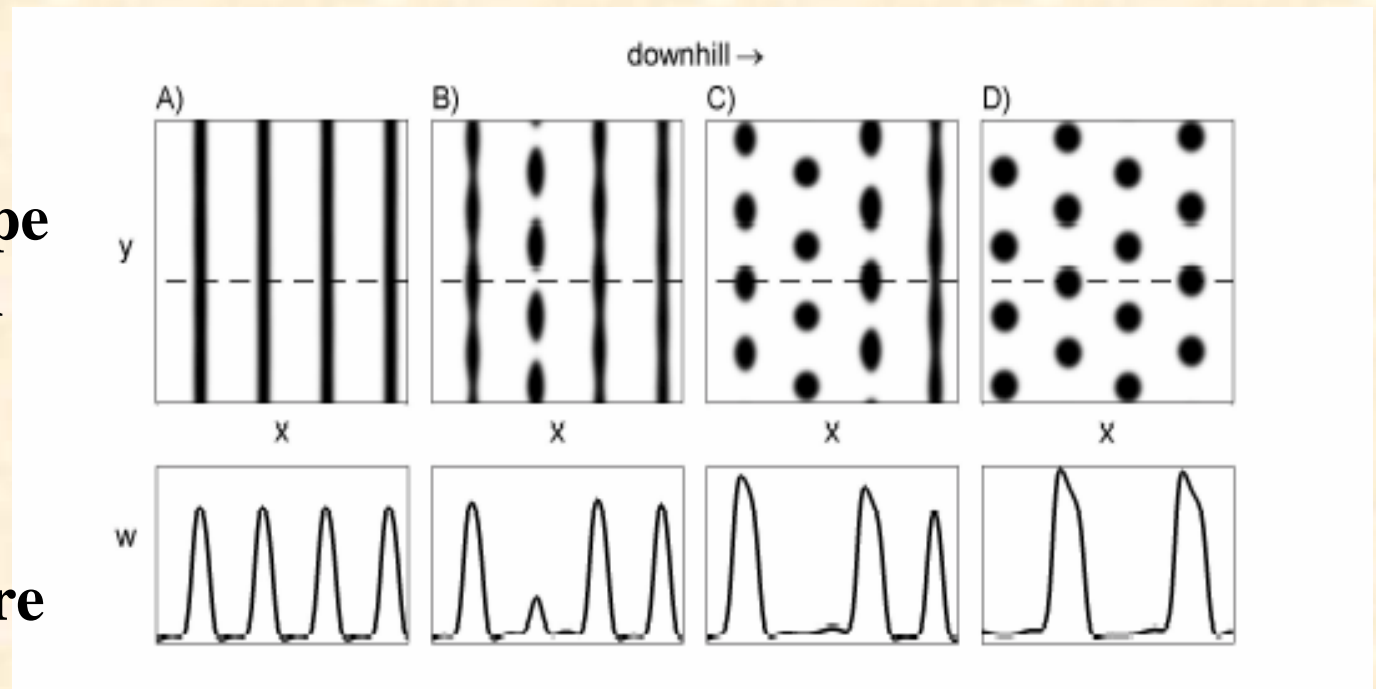


# CLIMATE CHANGE CRUST AND SHRUB STATES & HYDRO-ENGINEERING

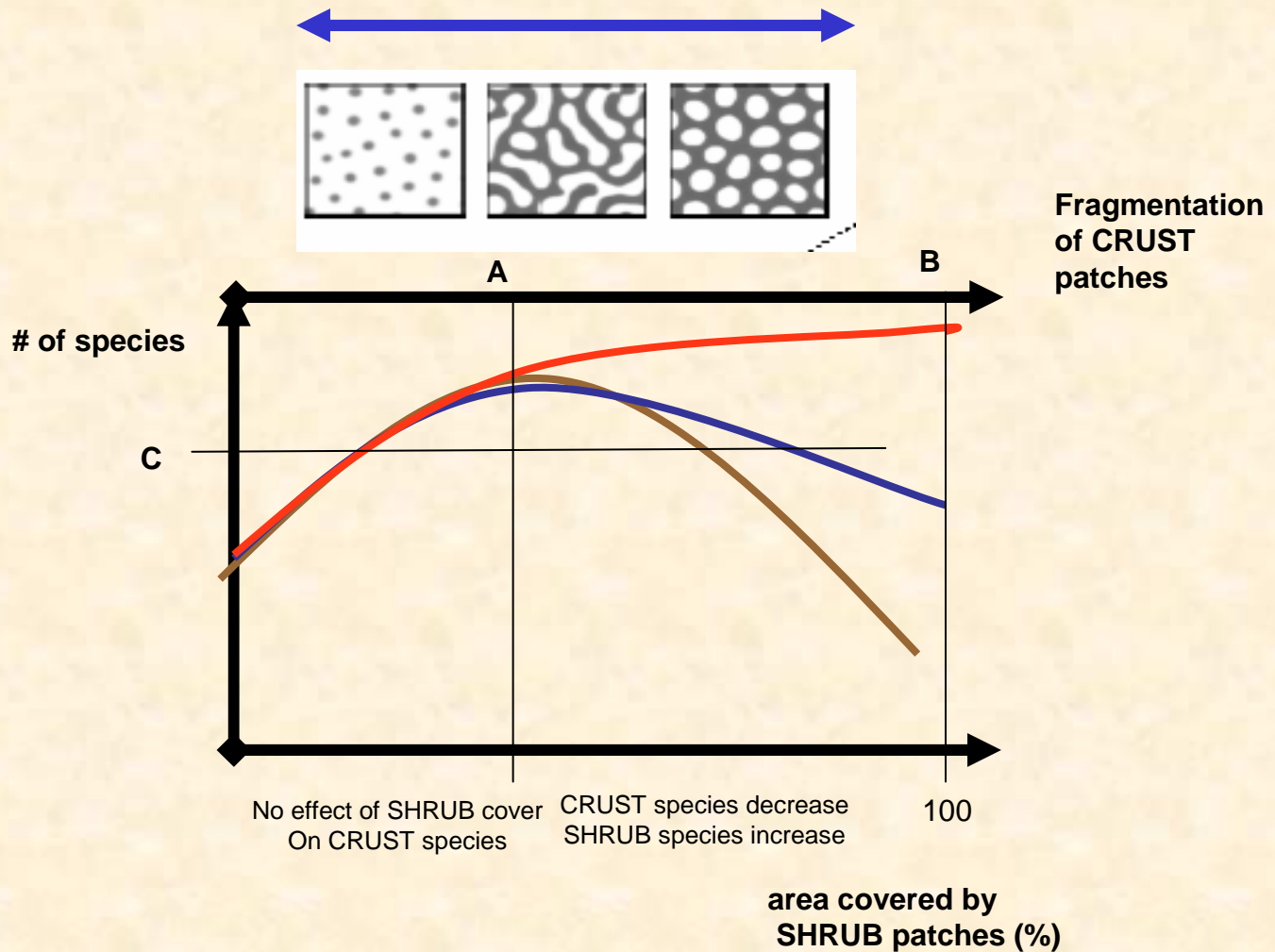
—————→ Aridification

Landscape  
pattern

Soil  
moisture



# CLIMATE CHANGE CRUST AND SHRUB STATES & SPECIES RICHNESS



# Summary:

- ❑ **Drylands are biotic induced landscapes**
- ❑ **The biotic landscape is generated by ecosystem engineers**
- ❑ **The biotic patchiness controls water flow, soil processes  
biomass production and species filtering across spatial  
scales**
- ❑ **Climate change effects on ecosystem engineers may cause  
state transition due to changes in: landscape pattern,  
engineering properties and species richness and composition**