The Royal Academy of Engineering

Global Research Awards

# Unifying Concepts in the Design of Biological Treatment Systems

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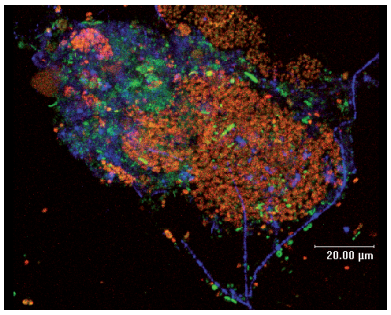
## Problem: poor theoretical foundation of design

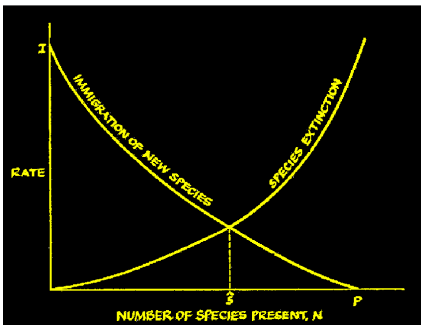
Engineered biological treatment systems occupy are central to sustainable urban future. They are typically empirically designed systems of unimaginable complexity and can fail inexplicably. Molecular biology has brought us powerful new tools with which to measure and characterize these systems. However, we cannot exploit these new insights in design because of our poor theoretical understanding of how biological systems work.

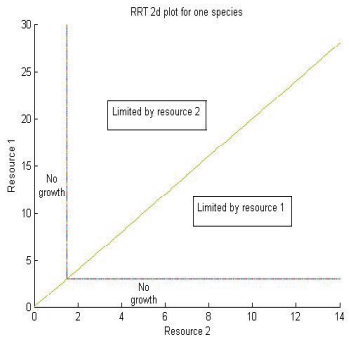



*Phosphorous removing bacteria labelled by fluorescent in situ hybridisation of the rRNA*

## Challenge: to adapt "traditional" theoretical ecology to design

Theoretical ecology has undergone a revolution since the early 1960s when engineers invoked simple Monod based models in design. There is now a rich theoretical literature that purports to predict ecosystem composition, dynamics and function. A Global Research Award allowed me time to "cherry pick" this literature to develop new approaches to design.



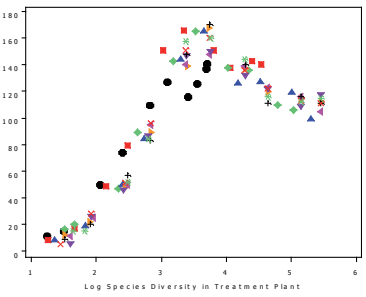

*Classical ecological theories: island biogeography (left); resource ratio theory (right).*

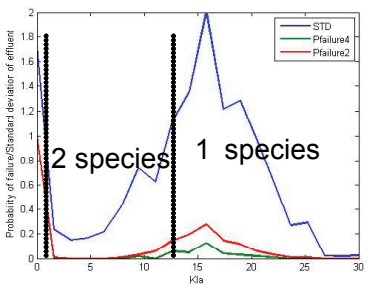
## Progress

Workable, calibrated and but preliminary approaches were devised and used to predict the diversity in biological treatment systems and how this affects performance.

## The future

Classical ecological theory can provide a basis for design. The corroboration of the models is a technical challenge. Ultimately, we need to go beyond contemporary ecological theory in which calibration and prediction are undervalued.




*Predictions in engineered systems: of diversity (left) and the effect of diversity on energy use (right).*

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