Population dynamics is the study of how and why population numbers change in time and space


In The Beginning…
Population fluctuations of animals have been recognized for millenia
However, scientific study relatively recent
Both mathematical exploration and empirical approaches; human demography and applied pest management

Early Roots…
Thomas Malthus
“An essay on the principle of population” published 1798 –went through 6 editions
Discussed issue of limited food supply for humanity – early population regulation!
Human population limited by pestilence and famine – perfectability of society limited

Population Dynamics: A Brief History
Objectives:
1. Review development of field
2. Introduce some of the key people and ideas
3. Summarize current state of affairs


There is something fascinating about science. One gets such a wholesale return of conjecture out of a trifling investment of fact.”

-Mark Twain
Early Roots...

Pierre François Verhulst
Published the logistic equation in 1838
Key idea: forces that prevent population growth increase proportionally as a function of the “excess” population
Decided it wasn’t a “law” because not clear how exactly to mathematically describe “obstacles to growth”.

Back on the Farm...

Hatch Act 1887-
Agriculture experiment stations
Emphasis on understanding and controlling pest outbreaks in ag
Development of a more scientific basis for the study of natural history

Understanding population growth
The mathematical approach

Alfred Lotka
Physical chemist by training and vocation! Later, a professional demographer
Author of “Elements of Physical Biology” application of physical principles to biological systems. Later republished as “Elements of Mathematical Ecology”
Predator-prey oscillations, and Vito Volterra
Mathematical models as powerful aids to understanding

Understanding population growth
The mathematical approach

Raymond Pearl
Human demographer and biometrician
“Discovered” Lotka, collaborated extensively
Major proponent of quantitative demography e.g., “The Biology of Population Growth”
Sought “law” of population growth- and latched onto the logistic equation
Work with Lowell J. Reed on logistic equation quite controversial!
Understanding population growth
The mathematical approach

William Thompson, 1887-1972

Understanding population growth
The empirical approach

Charles S. Elton, 1900-1991

Elton’s Contributions…
1924: *Fluctuations in the numbers of animals, their causes and effects* (Br. J. Expl. Biol).
1931: Study of epidemic diseases among wild animals
1942: *Voles, Mice and Lemmings: Problems in Population Dynamics*
1958: *The Ecology of Invasions by Animals and Plants*

Elton’s Contributions…
1932: Began the Bureau of Animal Populations
1932: founded Journal of Animal Ecology

See “Do Lemmings Commit Suicide? Beautiful Hypotheses and Ugly Facts” by D. Chitty for an insider view of Elton and his legacy

From the Laboratory
Experimental studies of populations with Drosophila, Tribolium, and others
Questions of genetics, evolution, life history, population dynamics
Applying demographic techniques first developed for humans (Pearl)

A new idea…

*Were population fluctuations actually the result of internal dynamics rather than external forces?*

This arose from modeling and the lab, whereas field studies by Elton and others had concentrated on external environmental drivers
Population Regulation
The Great Density Dependence Debate
What stops populations from growing? “internal” versus “external” factors
David Lack, “Natural Regulation of Animal Numbers” (1954)

Through the 50’s and 60’s
The ecological niche
Georgii Gause
G. Evelyn Hutchinson
David Lack
Implications for Population Ecology

Robert MacArthur
The tension over place and history

“Models for Dummies”
Robert MacArthur and Richard Levins
Levins’ view:
Generality
\Precision
Realism
You can only have two out of three!

Understanding Growth of Populations
Approaches to Developing and Evaluating Hypotheses and Theory

\begin{align*}
A \text{ \textit{posteriori}} & : \quad \text{Pearl} \\
& \quad \text{Elton} \\
& \quad \text{Thompson} \\
& \quad \text{Bailey} \\
& \quad \text{Lotka} \\
\end{align*}

\begin{align*}
A \text{ \textit{priori}} & : \quad \text{Nicholson} \\
& \quad \text{MacArthur} \\
\end{align*}

The Role of Theoretical Models In Population Ecology
Seeking simple, unifying “laws” of nature
\begin{align*}
\text{Verhulst, Pearl} & \\
\text{Lotka} & \\
\text{Thompson, Gause, Hutchinson, MacArthur} & \\
\end{align*}
Seeking general patterns for further experimental exploration
The Next Generation

Graeme Caughley
1937 - 1994

Peter Kareiva
Peter Turchin
Robert May

and many others...

A Modern Convergence?

And Currently...

Ever-greater sophistication in quantitative tools
Enduring tension between theory and observation, “pure” and “applied” science
Biological knowledge crucial!

Conclusions

Population ecology and dynamics rooted in economics, physical sciences, and human demography

Early tensions over role of theory and mathematical modeling versus detailed natural history studies still resonate

Continuing controversy over role of regulation, existence of laws, and influence of history