Quelques flâneries à propos des forêts hétérogènes

Alain Franc
UMR BioGeCo

Pourquoi est-ce si difficile

d'étudier les forêts hétérogènes ?

OIKOS 84: 177–192. Copenhagen 1999

Are there general laws in ecology?

John H. Lawton

Lawton, J. H. 1999. Are there general laws in ecology? – Oikos 84: 177–192.

The dictionary definition of a law is: "Generalized formulation based on a series of events or processes observed to recur regularly under certain conditions; a widely observable tendency". I argue that ecology has numerous laws in this sense of the word, in the form of widespread, repeatable patterns in nature, but hardly any laws that are universally true. Typically, in other words, ecological patterns and the laws, rules and mechanisms that underpin them are contingent on the organisms involved,

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Forêt boréale

Forêt tempérée fraîche

M.Pitsch - INRA

Forêt appalachienne

Forêt tropicale humide

Diversité et modélisation

Forest type	Diversity		
	Variety of life	Algorithmic Complexity	Efficiency of models
Boreal Forest	low	low	high
European Temperate Forest	moderate	moderate	medium
Appalachian Broadleaves Forest	medium	medium	moderate
Tropical Rainforest	high	high	low

Forêts boréales

Proches de populations

souvent mono-, ou pauci-spécifiques

souvent équiennes y compris en régime naturel (feu)

Convergence entre

biologie des populations (démographie, génétique)
écophysiologie (de la pinède landaise) de peuplements big leaf
liens naturels et souples avec les modèles pour la gestion

Modèle forêt boréale

Forêts boréales

Forêts issues de plantations (Landes, forêt d'Orléans)

Grands feuillus sociaux (Hêtre, chêne, érablières nord-américaines)

Connaissance et gestion de populations

Longue tradition commune avec l'agronomie
avec un autre objet
un autre pas de temps
des systèmes plus naturels (intrants, non construction des génomes)

Quoique : gradient mais – peuplier - pin maritime – pin sylvestre - ?

Gap models

D'après Shugart

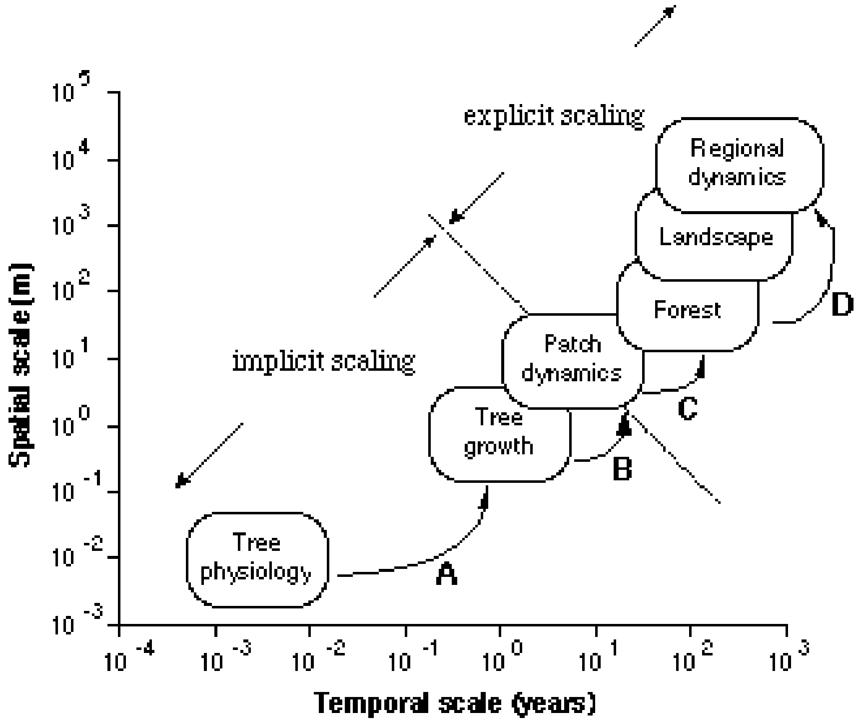
FORET-derived models

1. FORET (Shugart and West, 1977; Shugart, 1984). Southern Appalachian deciduous forest.
2. BRIND (Shugart and Noble, 1981). Australian eucalyptus forest.
3. KIABRAM (Shugart *et al.,* 1981). Australian subtropical rain forest.
4. FORICO (Doyle, 1981). Puerto Rican Montane rain forest.
5. SMAFS (El Bayoumi *et al.,* 1984). Eastern Canadian mixed-wood forest.
6. CLIMACS (Dale and Hemstrom, 1984). Pacific North-west coniferous forest.
7. FORFLO (Pearlstine *et al.,* 1985). Southern floodplain forest.
8. FORCAT (Waldrop *et al.,* 1986). Oak/hickory forest. .
9. FORSKA (Leemans and Prentice, 1987) Scandinavian forest.
10. FORECE (Kienast, 1987). Central European forest.
11. FORANAK (Busing and Clebsch, 1987). Montane boreal forest.
12. ZELIG (Smith and Urban, **1988**). Boreal-temperate forest transition.
13. LOKI (work in progress). Circumpolar boreal forest.
14. MANGRO (work in progress). Caribbean mangrove forest.
15. OUTENIQUE (work in progress). African temperate rain forest.

Other gap models

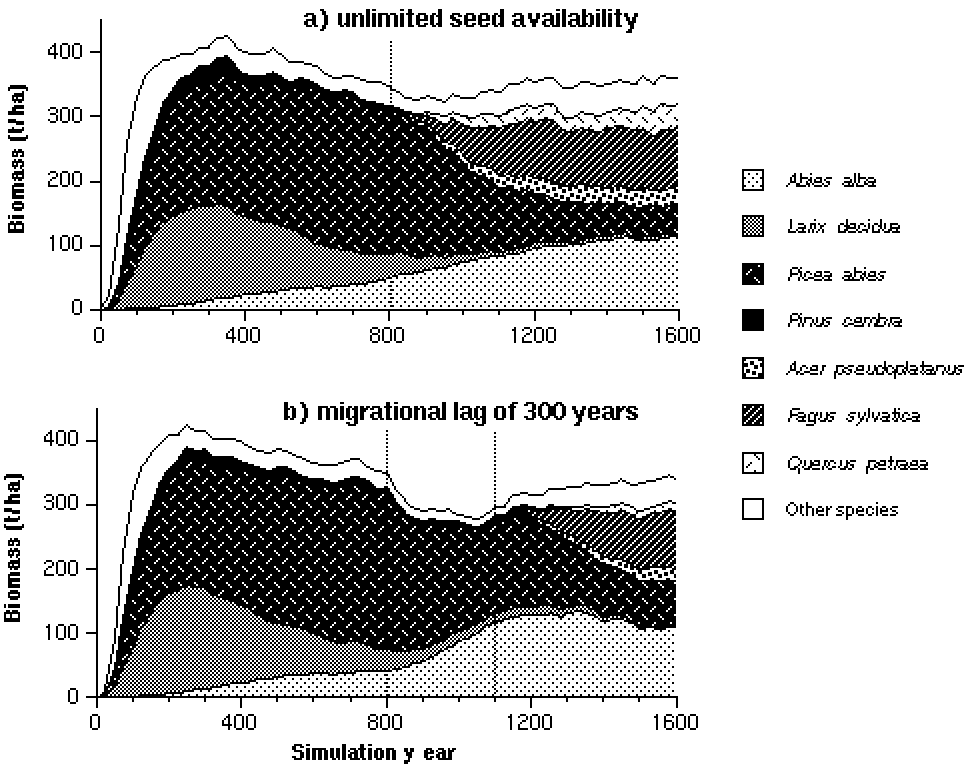
16. **JABOWA (Botkin *et al.,* 1972).** Northern hardwood forest.
17. FORTNITE (Aber and Melillo, 1982). Wisconsin mixed-wood forest.
18. SWAMP (Phipps, 1979). Arkansas floodplain model.
19. SJABO (Tonu, 1983). Estonian conifer forest.
20. SILVA (Kercher and Axelrod, 1984). Mixed conifer forest.
21. LINKAGES (Pastor and Post, 1986). Temperate boreal transition.

Echelles dans les gap models



Urban, Bugmann

Dynamique à long terme



Bugmann, 1996

Une « thèse »

Revitaliser l'écologie des communautés complexes

aux échelles intermédiaires

Dans un contexte d'emboitement d'échelles

Complexité intermédiaire

Evoluer de la gestion de populations vers la gestion de communautés

Communautés d'arbres, végétales, avec pathogènes, mycorizes

Analogie de questions
écologiques à explorer
avec les prairies permanentes

Enjeu difficile, très ouvert, à faibles bases conceptuelles stabilisées
Ouverture vers l'écologie des paysages

un contexte historique long en écologie des communautés végétale

~ 1800	Humboldt	Biogéographie
~ 1900	Phytosociologie assemblages locaux	
~ 1930	Clements, Gleason, Tansley : écologie végétale	
~ 1960	MacArthur, Hutchinson, Wilson Assemblages locaux comme fruits de processus écologiques	
~ 1980	Notion de métapopulation Ecologie du paysage Macroécologie	

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IDEAS AND PERSPECTIVES

A comprehensive framework for global patterns in biodiversity

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Abstract

The present study proposes to reconcile the different spatial and temporal scales of regional species production and local constraint on species richness. Although interactions between populations rapidly achieve equilibrium and limit membership in ecological communities locally, these interactions occur over heterogeneous environments within large regions, where the populations of species are stably regulated through competition and habitat selection. Consequently, exclusion of species from a region depends on long-term regional-scale environmental change or evolutionary change among interacting populations, bringing species production and extinction onto the same scale and establishing a link between local and regional processes.

Keywords

Beta diversity, community, competition, diversity, extinction, habitat breadth, local processes, regional processes, speciation, species richness.

Systématique et écologie

Systématiciens et biogéographes

La biodiversité globale est le fruit de l'histoire évolutive des taxons

Temps long, échelle continentale

Ecologues et biologistes des populations

La biodiversité locale est le fruit des interactions locales entre espèces

Peu de rôle à l'histoire

Rôle au hasard des dispersions

Interactions locales sous contrainte de l'environnement abiotique

Thèse de Robert Ricklefs

1. Les interactions locales changent les tailles des populations locales

2. La dispersion régionale « exporte » ces variations au-delà du périmètre des communautés locales

3. Aussi, les variations locales d'abondance se traduisent par des variations régionales (aires et habitats)

4. C'est notamment vrai pour les parasites
   Rôle des interactions biotiques

5. La dispersion crée des réseaux de populations mutuellement ajustées localement, relativement régulés (interactions versus dispersion)

6. Les extinctions dans ces réseaux proviennent de causes externes
   changement persistant de l'environnement abiotique
   évolution des traits des organismes en interactions

Patterns de diversité : local

Modèles de dynamique des populations type Lotka & Volterra

- principe d'exclusion compétitive
- modèles de réseaux trophiques
- diversification des « réponses fonctionnelles »

Théories de la coexistence

- niche (Hutchinson, 1957)
- limites de similarité

Règles d'assemblages des communautés

Paradigme : déterminisme local
la diversité locale est limitée par les interactions entre espèces, qui expliquent les patterns de diversité.

Patterns locaux : validation

L'équilibre reflète les conditions locales de milieu (stations forestières)

bien validé par les observations

diversité reliée à la disponibilité en ressources (matière, énergie)

Convergences (vicariance) en cas de pressions similaires

effets régionaux souvent significatifs

e. g. : non convergence de la diversité des arbres tempérés dans les quatre zones de l'Hémisphère Nord : Eurasie occidentale ; Asie orientale ; Appalaches ; Amérique du Nord, façade Pacifique.

Exemple des mangroves (océan Indien – Pacifique Ouest ; Caraïbes Pacifique est).

Diversité locale relativement indépendante de la diversité régionale ?

La diversité locale souvent corrélée positivement à la diversité régionale

Du local au global

Notion de saturation :	« carrying capacity » pertinente dans le cas des espèces invasives due à la géométrie des niches ?
Marche vers l'équilibre	rapide dans les mésocosmes certainement bien plus lente en milieu naturel population dans aire vaste et hétérogène rôle de la dispersion et des migrations
In natura	population sur de vastes aires dans des environnements hétérogènes avec interactions régionales

Global et évolution

Difficulté de déterminer la part des processus écologiques et de la diversification (radiation) au sein de régions

Il semble que les clades anciens (Tertiaires) soient plus riches et diversifiés que les clades récents (Quaternaire)

Les clades récents sont souvent emboités dans les clades anciens.

Conclusions

Les communautés locales (fermées) sont un leurre

Prise en compte simultanée des histoires et échelles régionales, et du déterminisme des assemblages locaux

La dispersion connecte les populations sur une grande région
L'étude des flux de gène peut permettre de quantifier et dater ces connexions

La vitesse de diversification des lignées (richesse régionale) peut s'obtenir à partir de larges phylogénies

L'adaptation locale et les migrations entre zones complètent les processus à l'échelle régionale

Dernière observation …

Type de forêt	Diversité	Modélisation	Stations forestières
Forêt boréale	Faible	Simple	Fonctionnelles
Forêt tempérée fraiche	Moyenne	Simple	Fonctionnelles
Forêt tempérée chaude	Forte	Imparfaite	En débat (Whittaker)
Forêt tropicale humide	très forte	Très imparfaite	Non pertinente