Biological Futures in a Globalized World

Are we researching our way into a deadly pandemic?

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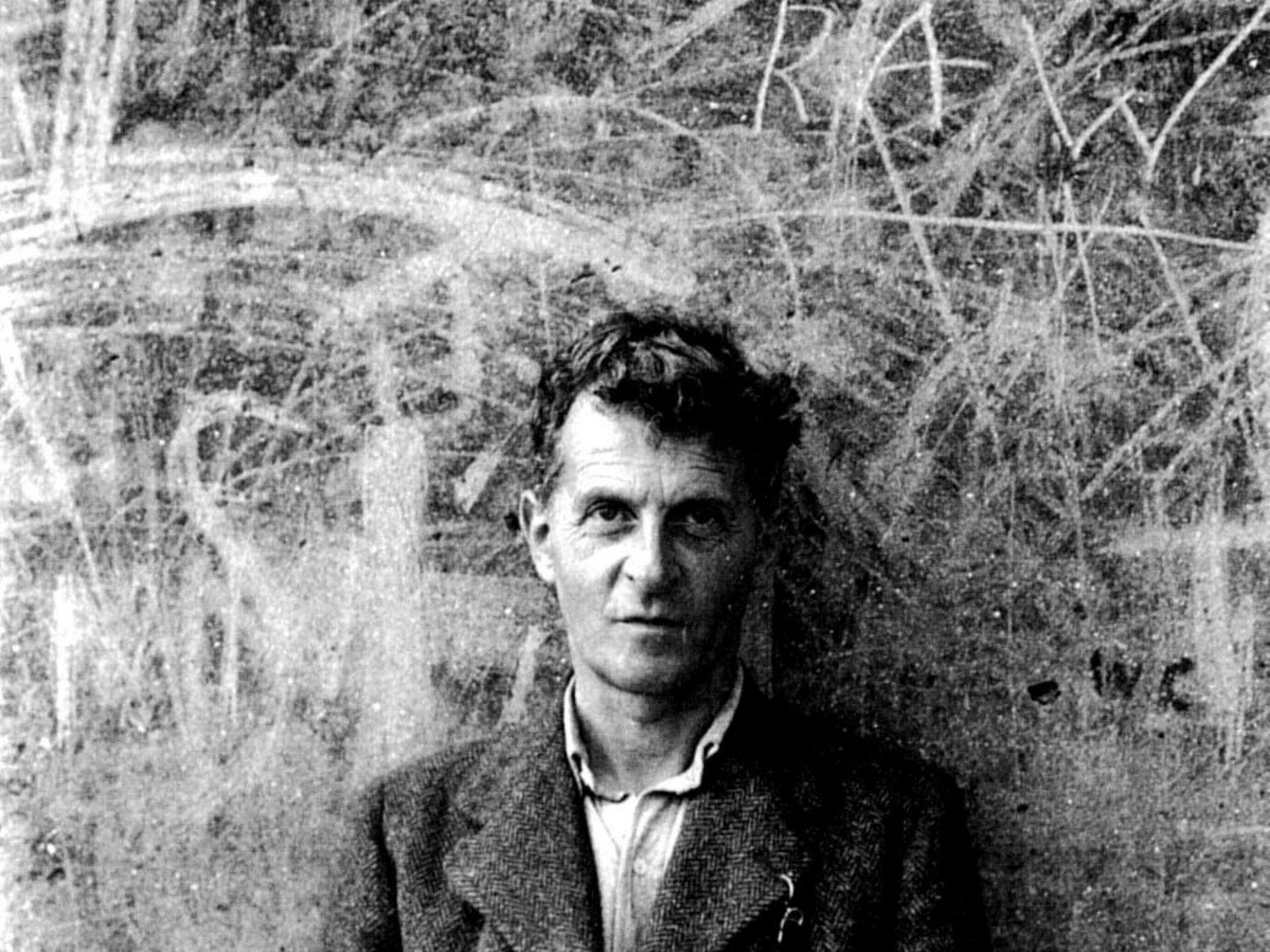
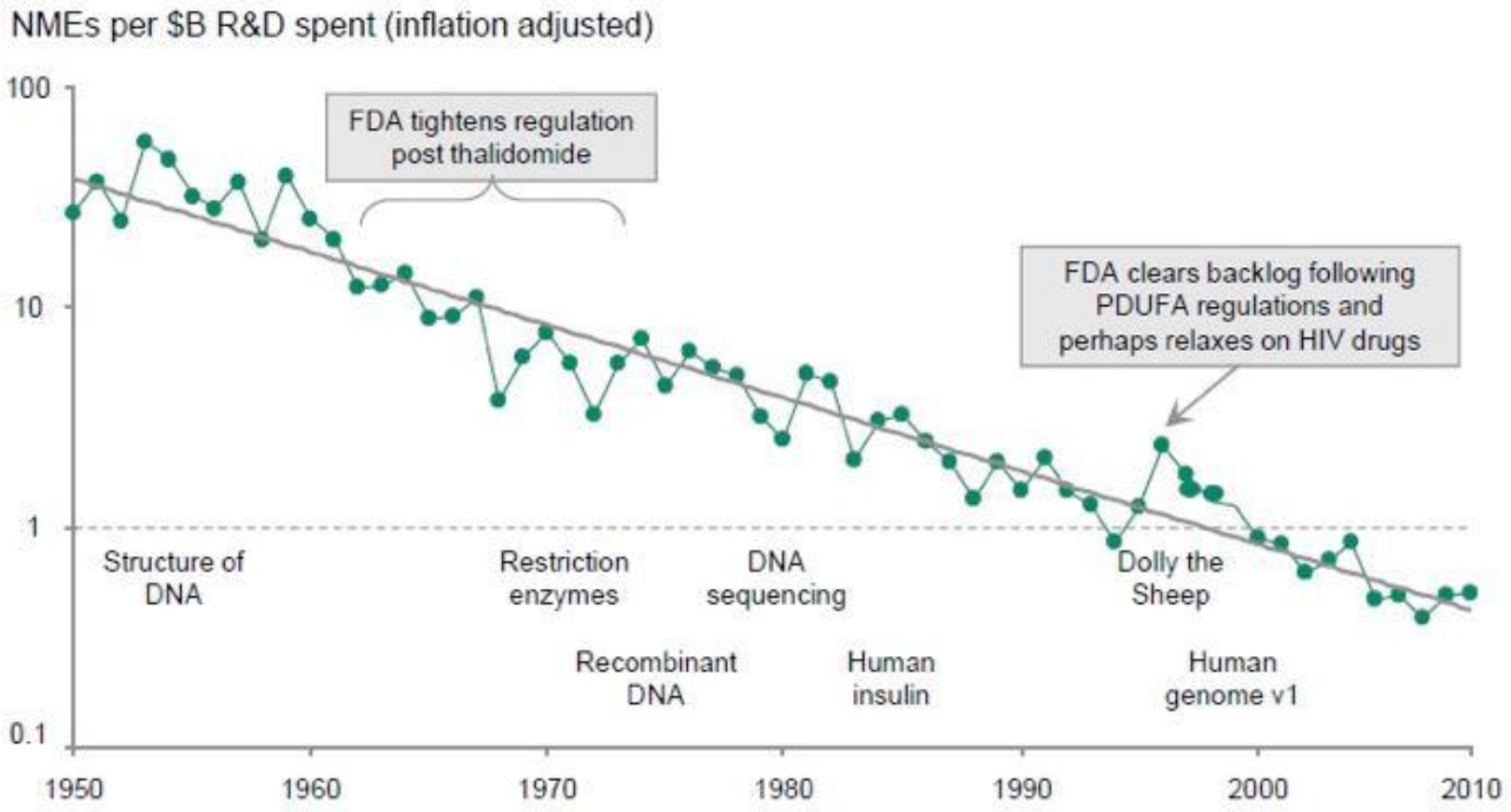
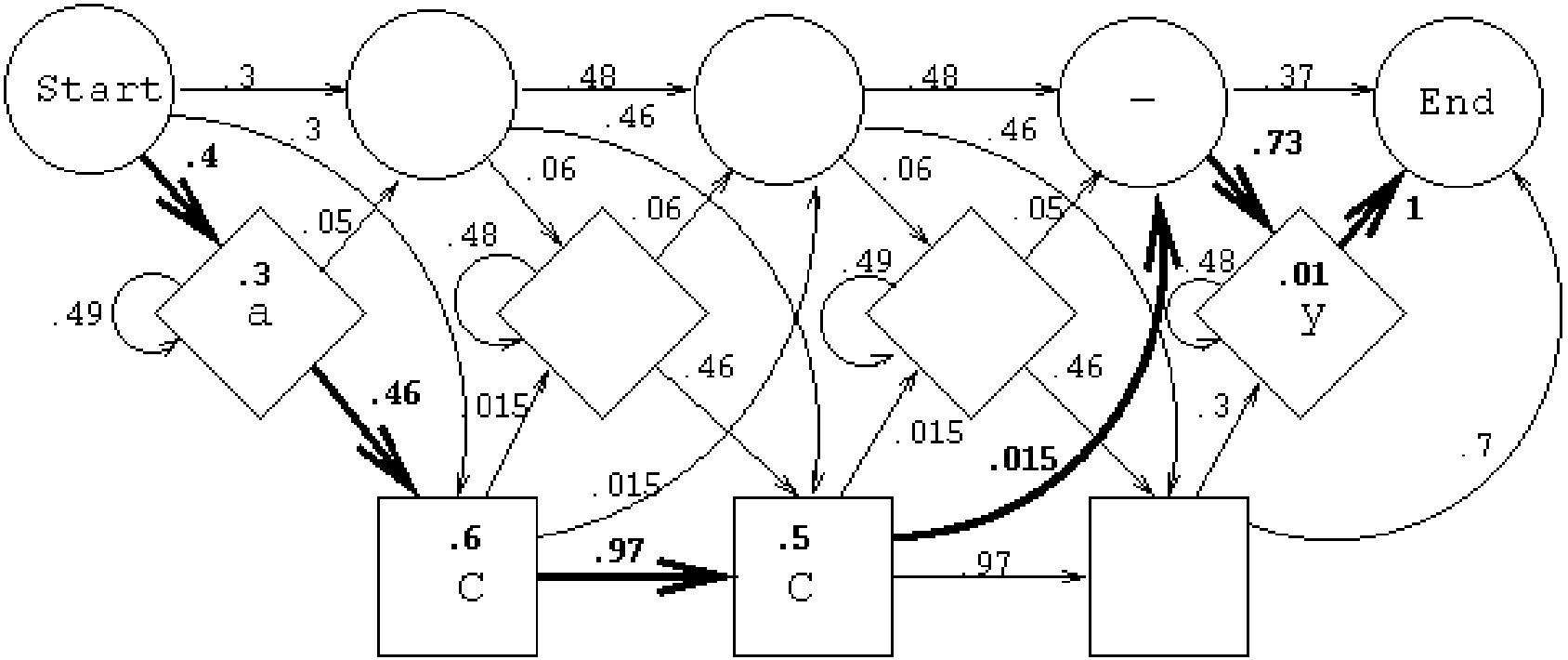
11 February 2013


RAW

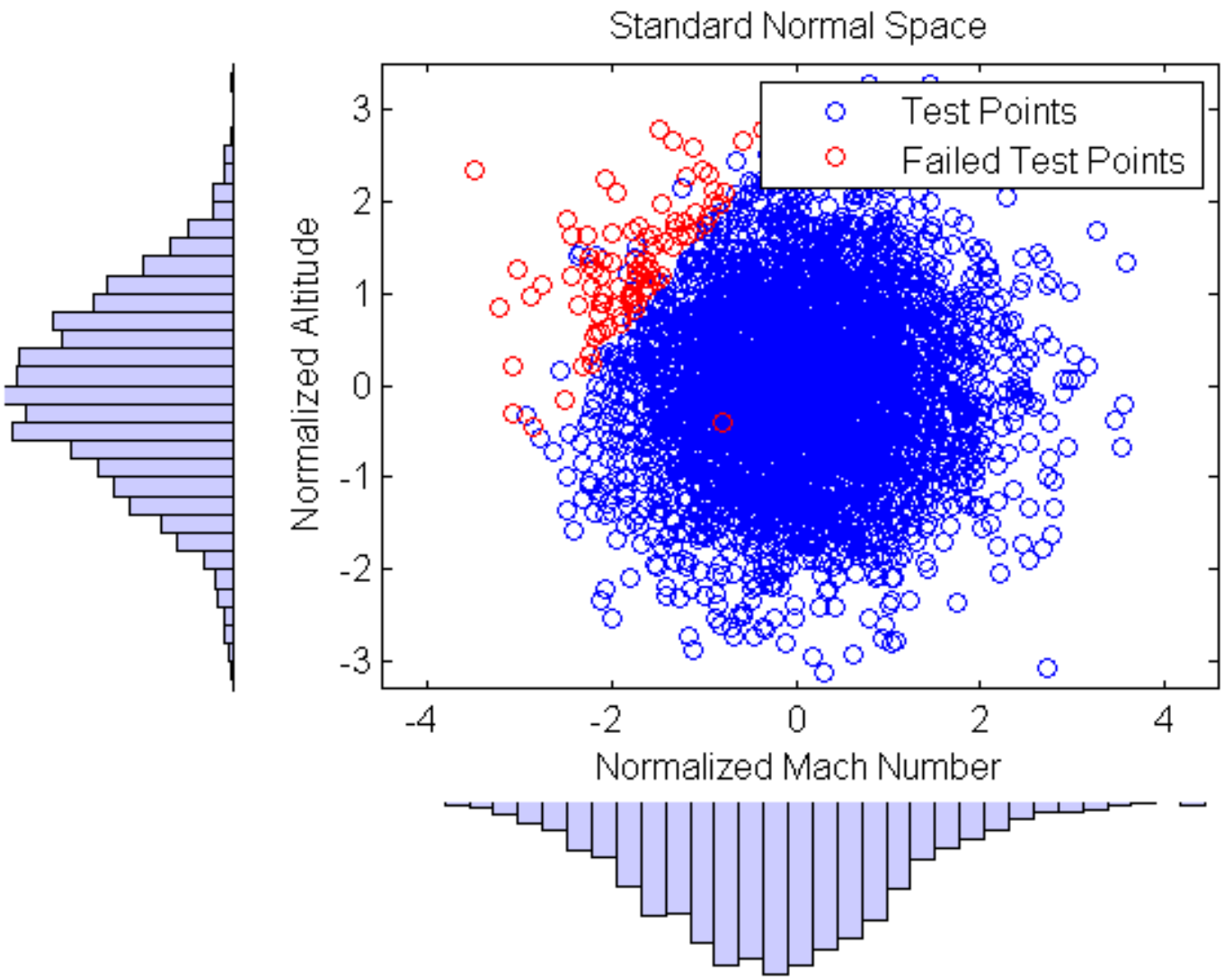


Note: R&D costs are estimated from PhRMA annual survey 2009; NMEs are the total number of small molecule and biologic approvals by the FDA
Source: Bernstein Research "The Long View – R&D Productivity" (September 30, 2010)

Markov chain process



Monte Carlo simulation



SIR modeling

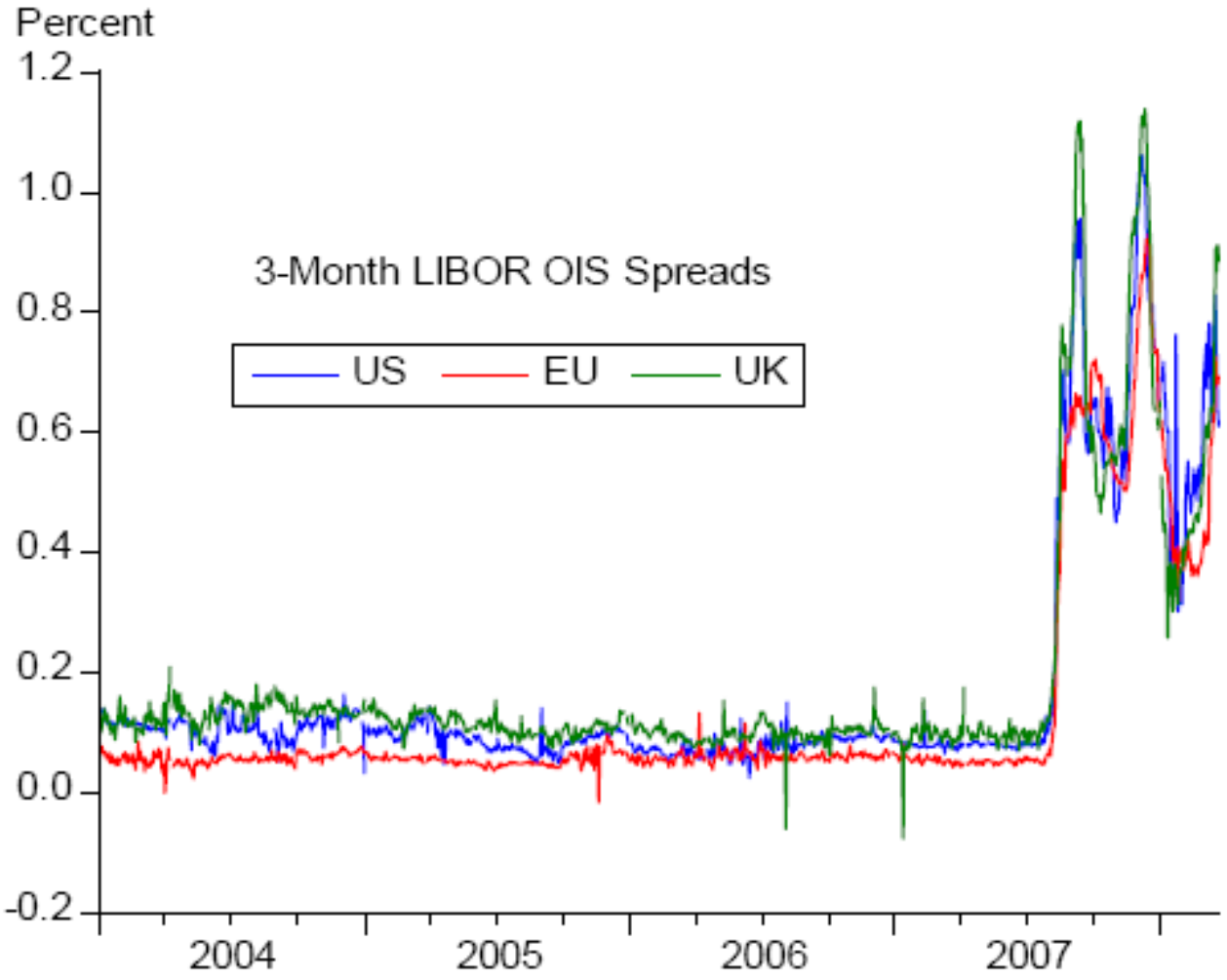
$$\frac{dS(t)}{dt} = -\beta\left(\frac{S(t)}{P}\right)I(t) + \alpha R(t) + \mu(P - S(t))$$

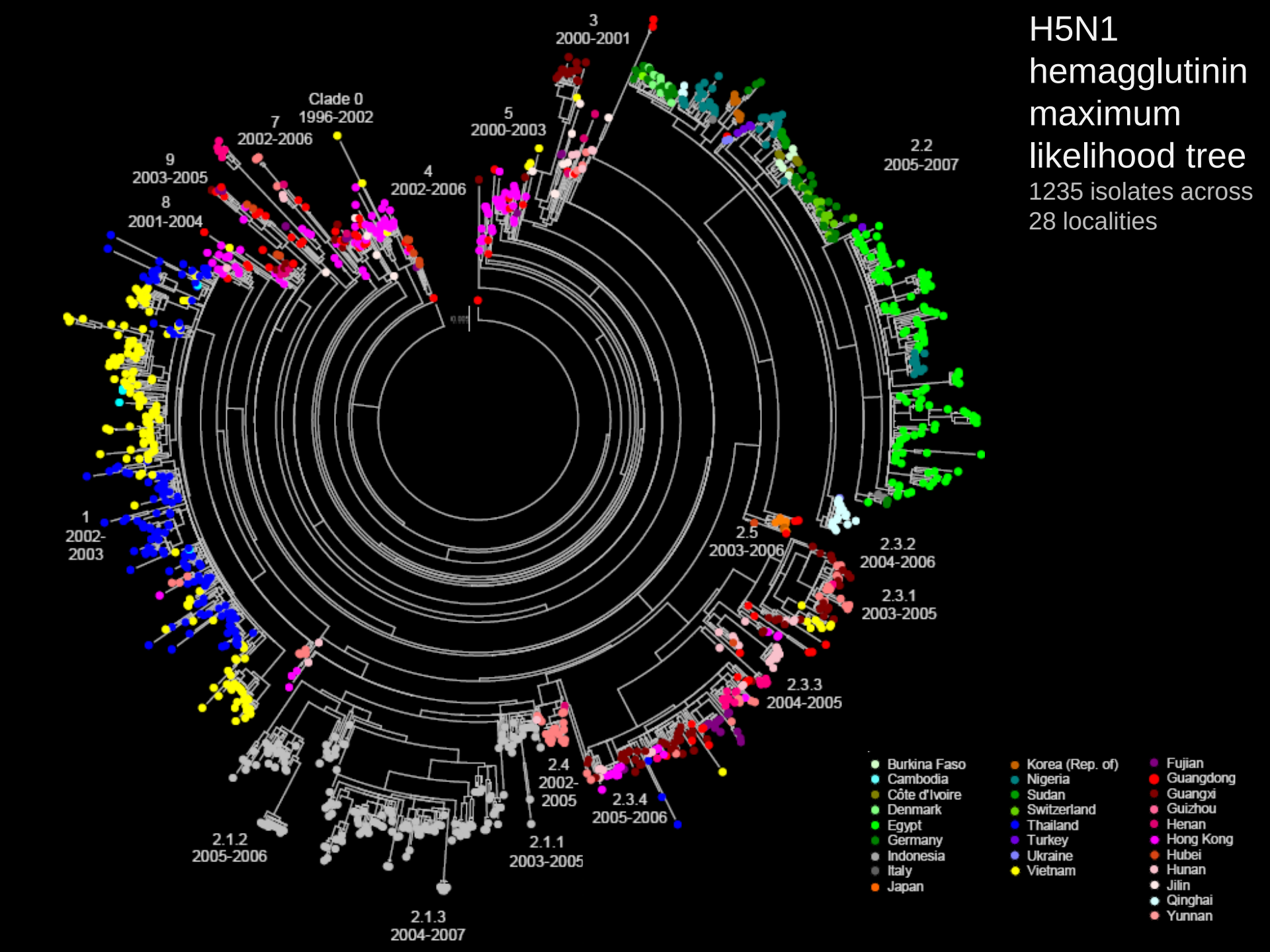
$$\frac{dI(t)}{dt} = \beta\left(\frac{S(t)}{P}\right)I(t) - \gamma I(t) - \mu I(t)$$

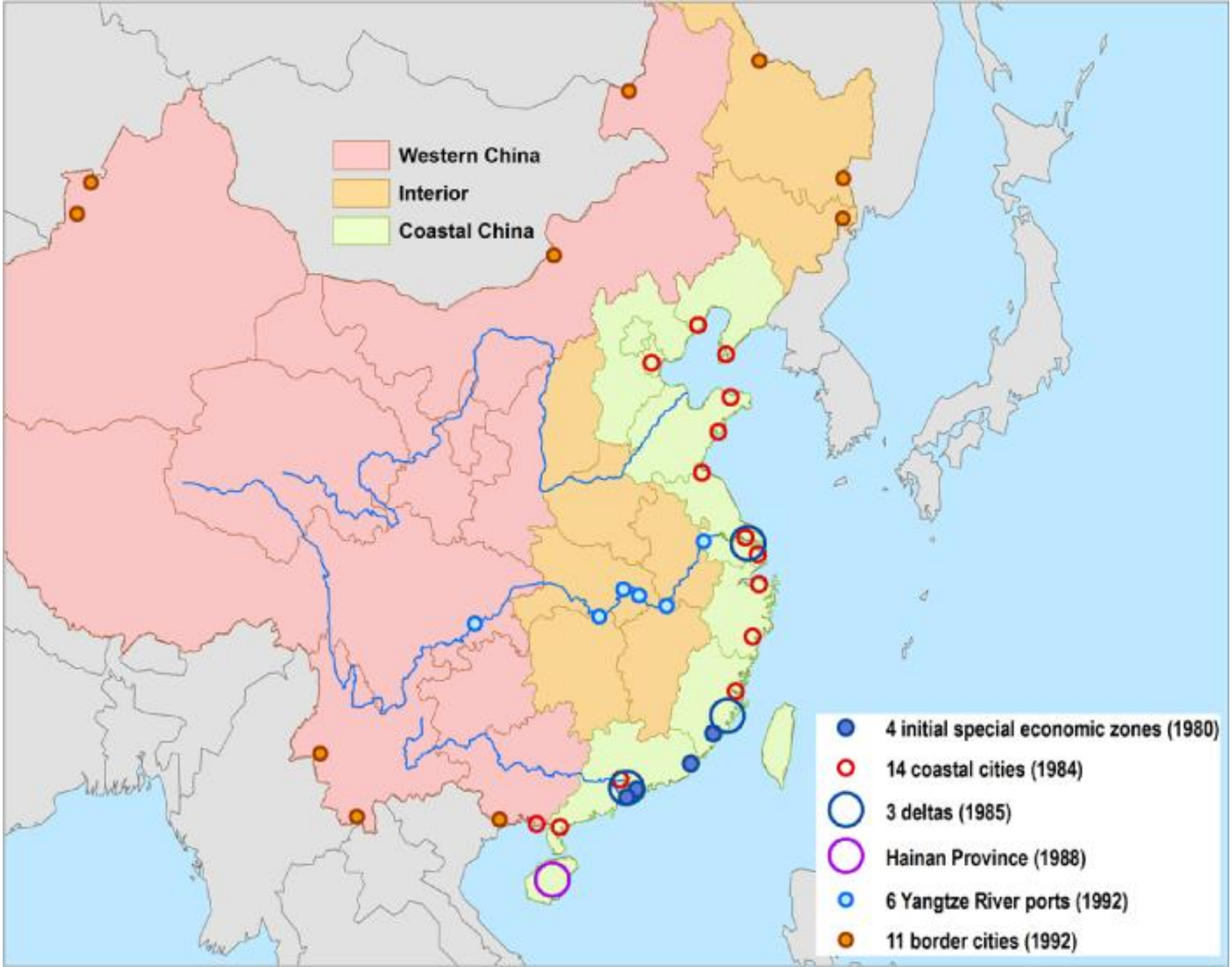
$$\frac{dR(t)}{dt} = \gamma I(t) - \alpha R(t) - \mu R(t)$$

Black Swan fractals

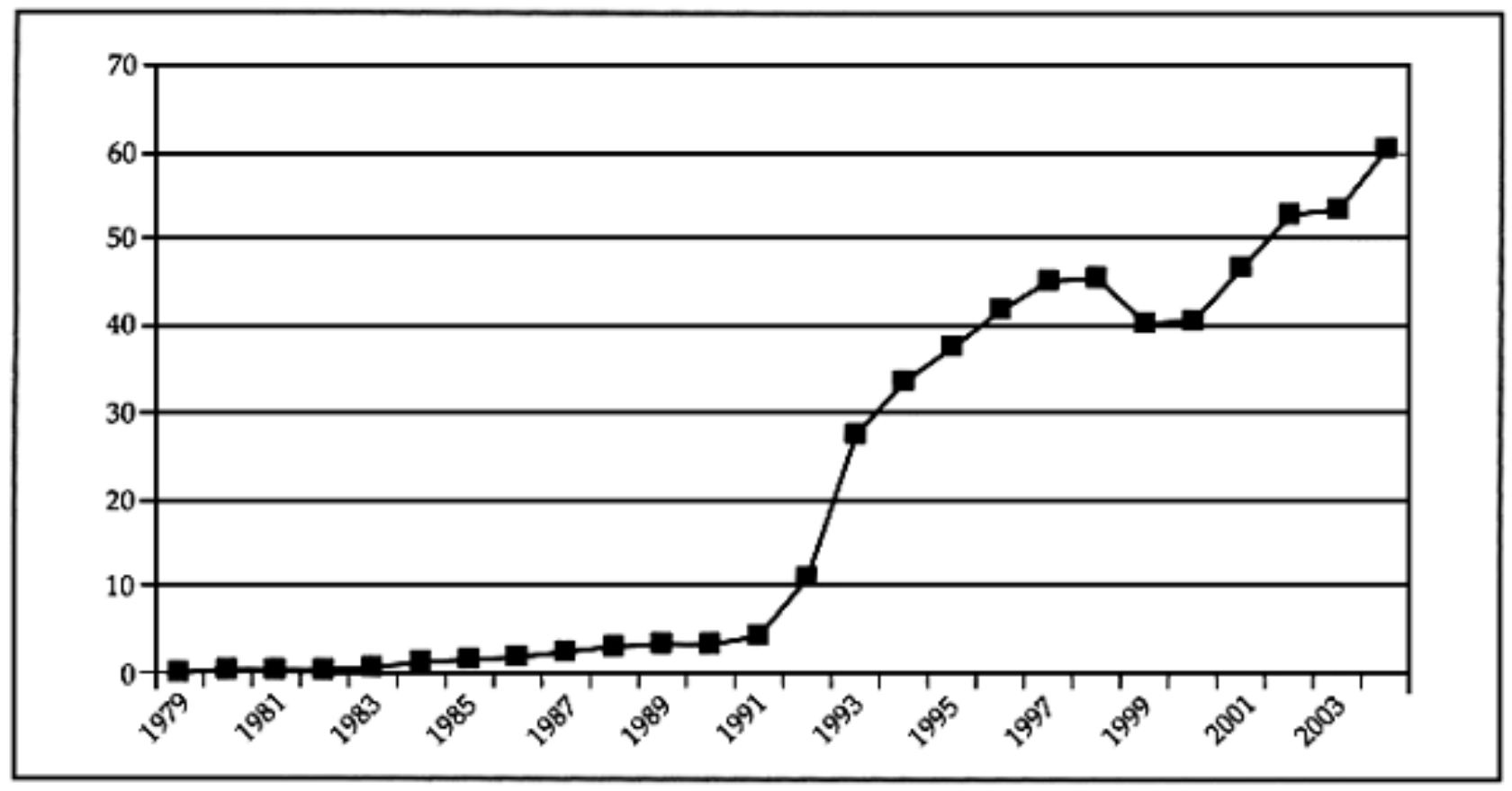
Red Swan instead?




H5N1 hemagglutinin maximum likelihood tree
1235 isolates across 28 localities
Clade 0
1996-2002
1
2002-2003
2.1.2
2005-2006
2.1.3
2004-2007
2.1.1
2003-2005
2.4
2002-2005
2.3.4
2005-2006
2.3.3
2004-2005
2.3.1
2003-2005
2.3.2
2004-2006
2.5
2003-2006
2.2
2005-2007
3
2000-2001
5
2000-2003
4
2002-2006
7
2002-2006
9
2003-2005
8
2001-2004
Burkina Faso
Cambodia
Côte d'Ivoire
Denmark
Egypt
Germany
Indonesia
Italy
Japan
Korea (Rep. of)
Nigeria
Sudan
Switzerland
Thailand
Turkey
Ukraine
Vietnam
Fujian
Guangdong
Guangxi
Guizhou
Henan
Hong Kong
Hubei
Hunan
Jilin
Qinghai
Yunnan

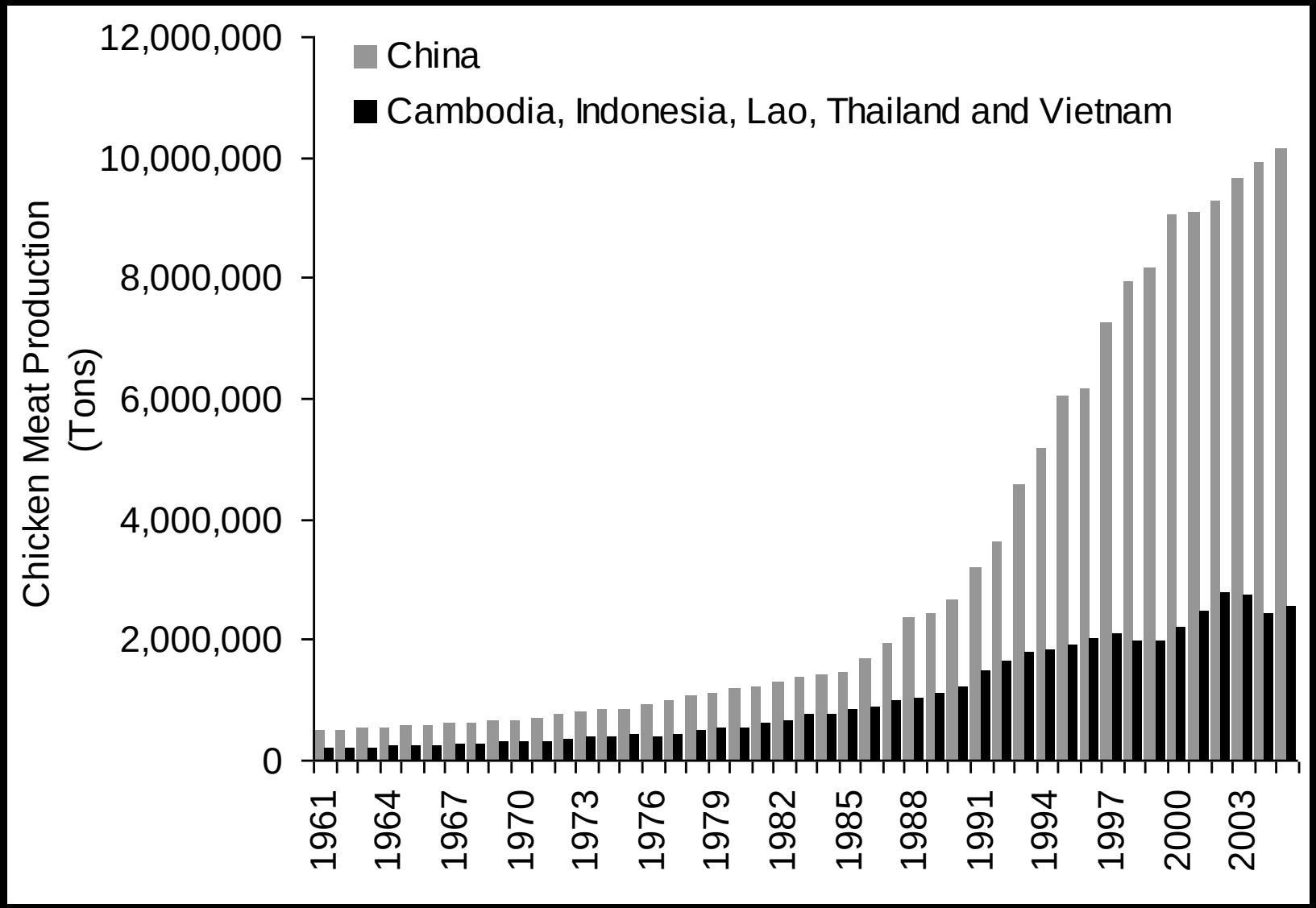

Western China
Interior
Coastal China
4 initial special economic zones (1980)
14 coastal cities (1984)
3 deltas (1985)
Hainan Province (1988)
6 Yangtze River ports (1992)
11 border cities (1992)

Inward FDI in China (US$ billion), 1979-2004



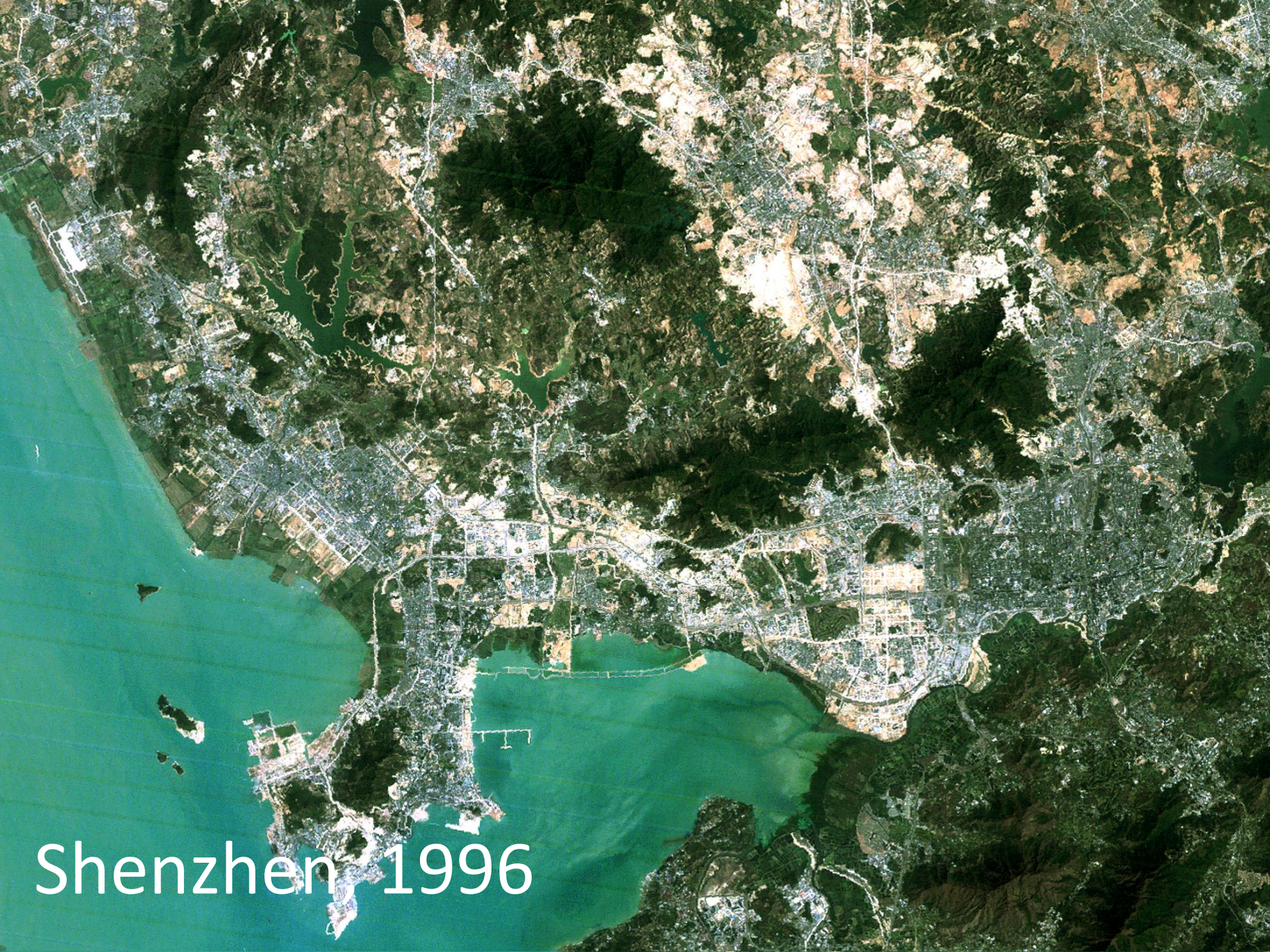
Source: NSBC (1990–2005)

Asian chicken production

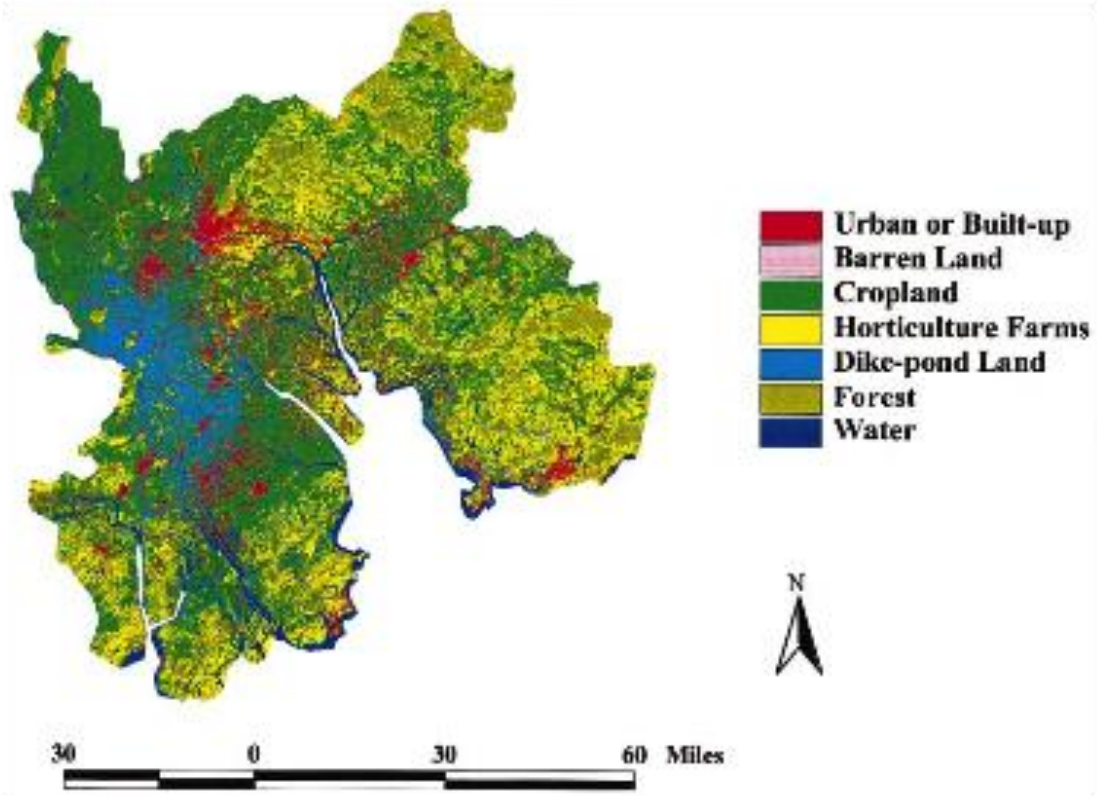


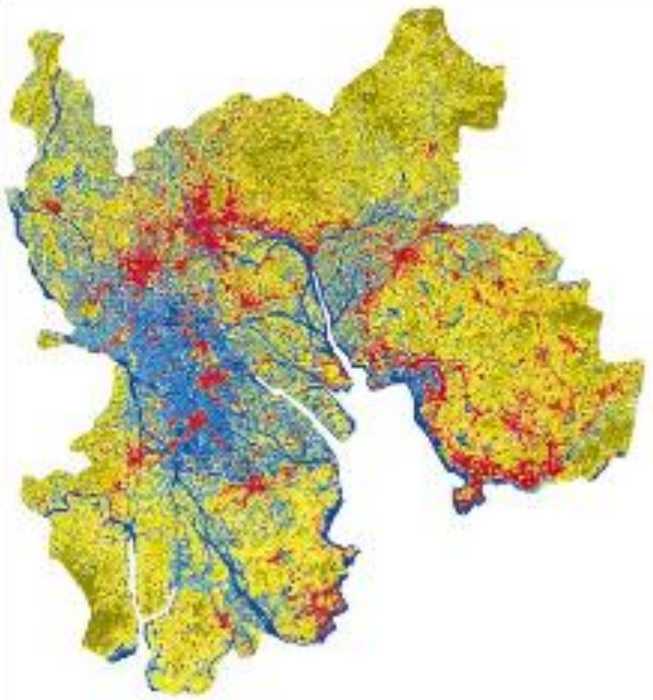
Gilbert *et al.* in press


Shenzhen, 1988


Shenzhen 1996

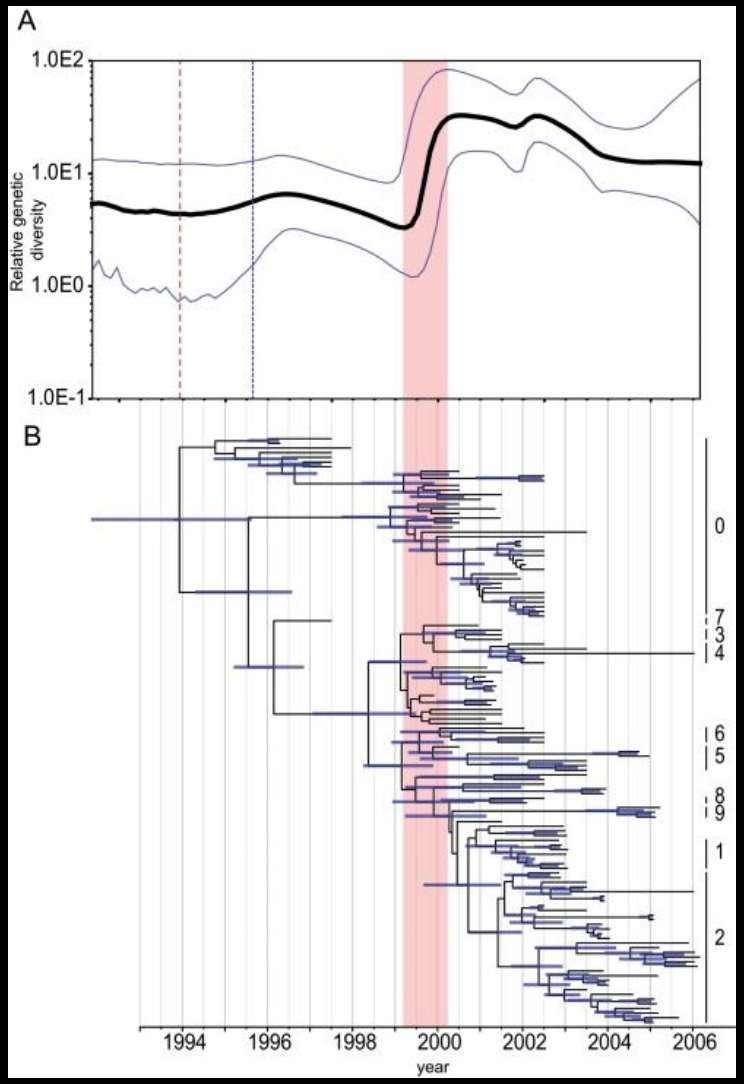
Pearl River Delta, 1989 and 1997

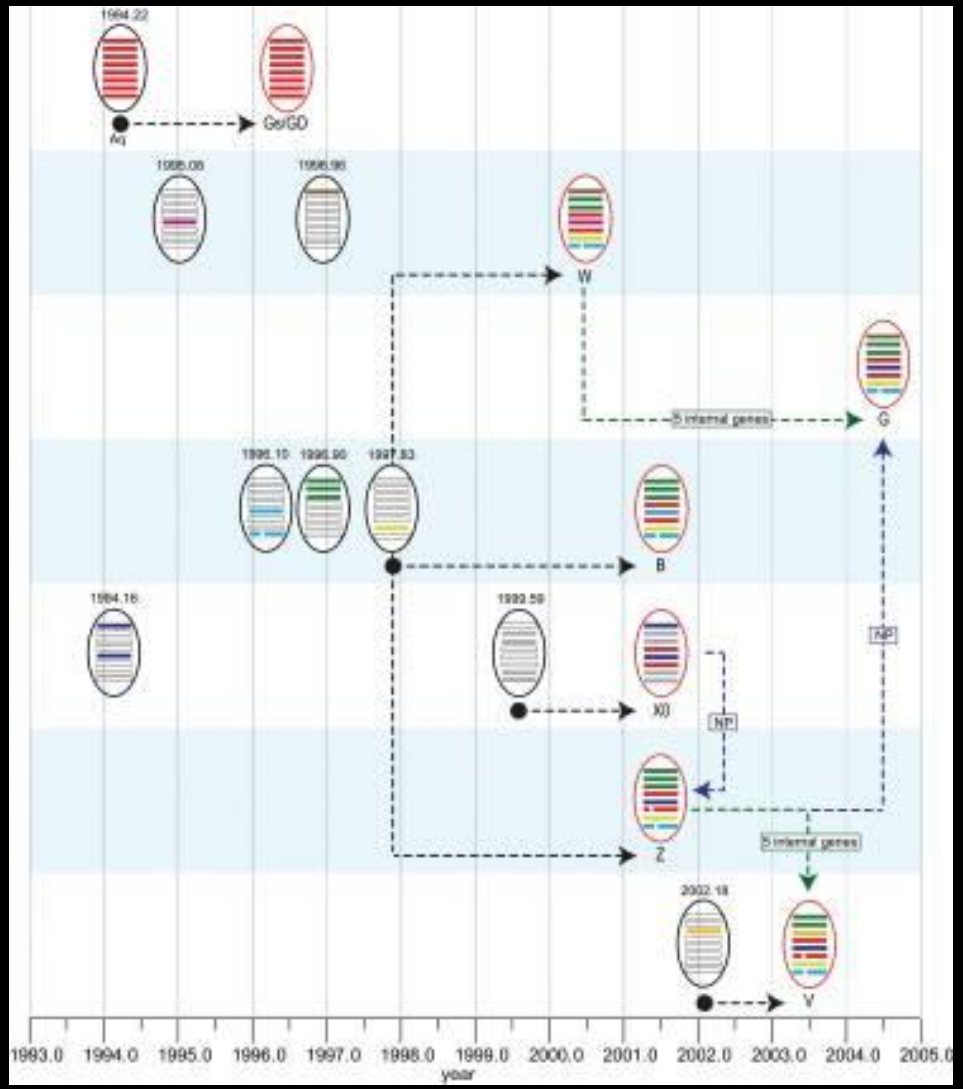




Weng (2002)

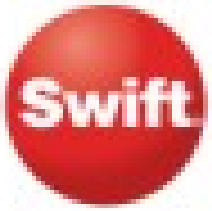
Phylogenetic evidence





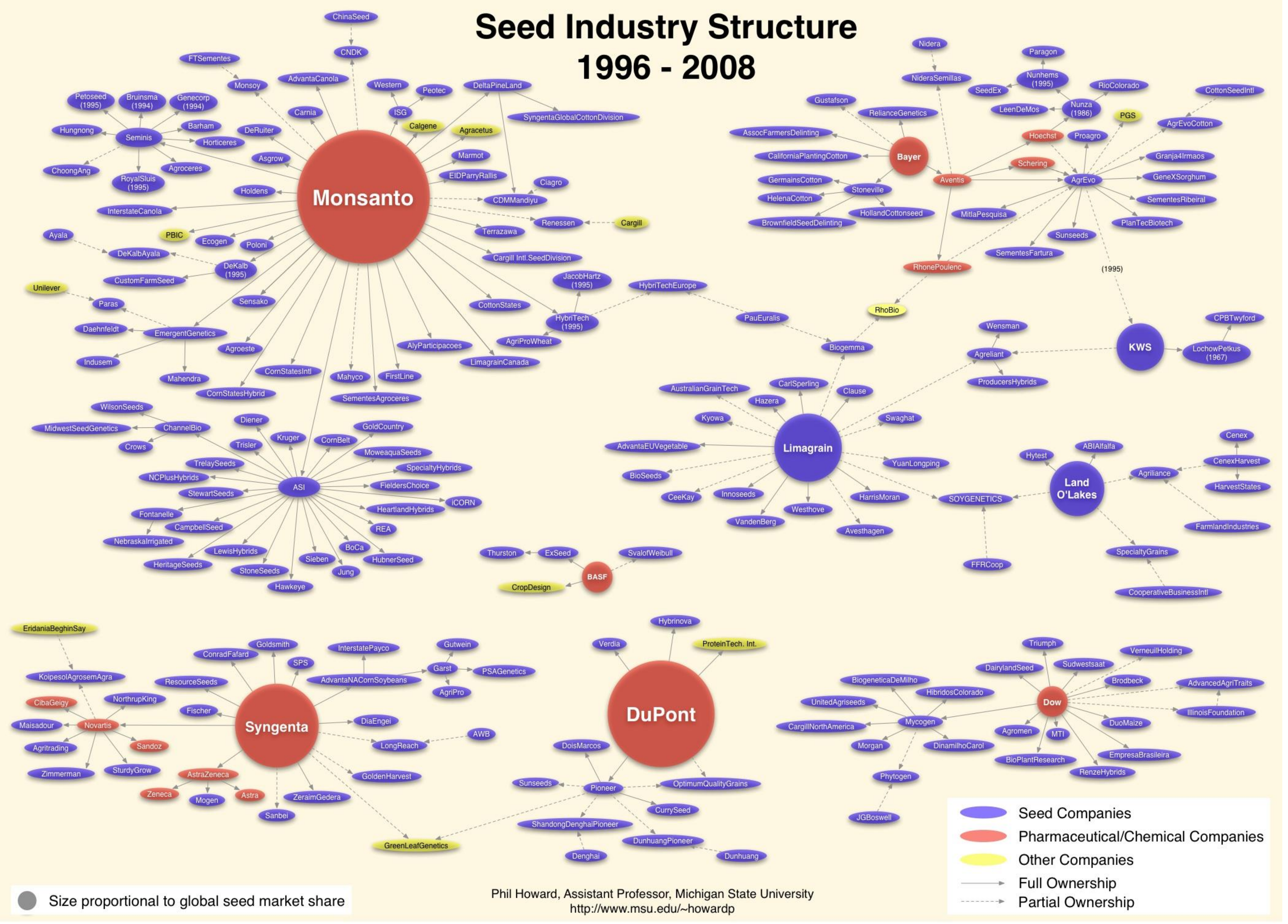
Vijaykrishna *et al*. (2008)

Swine flu H1N1 (2009)

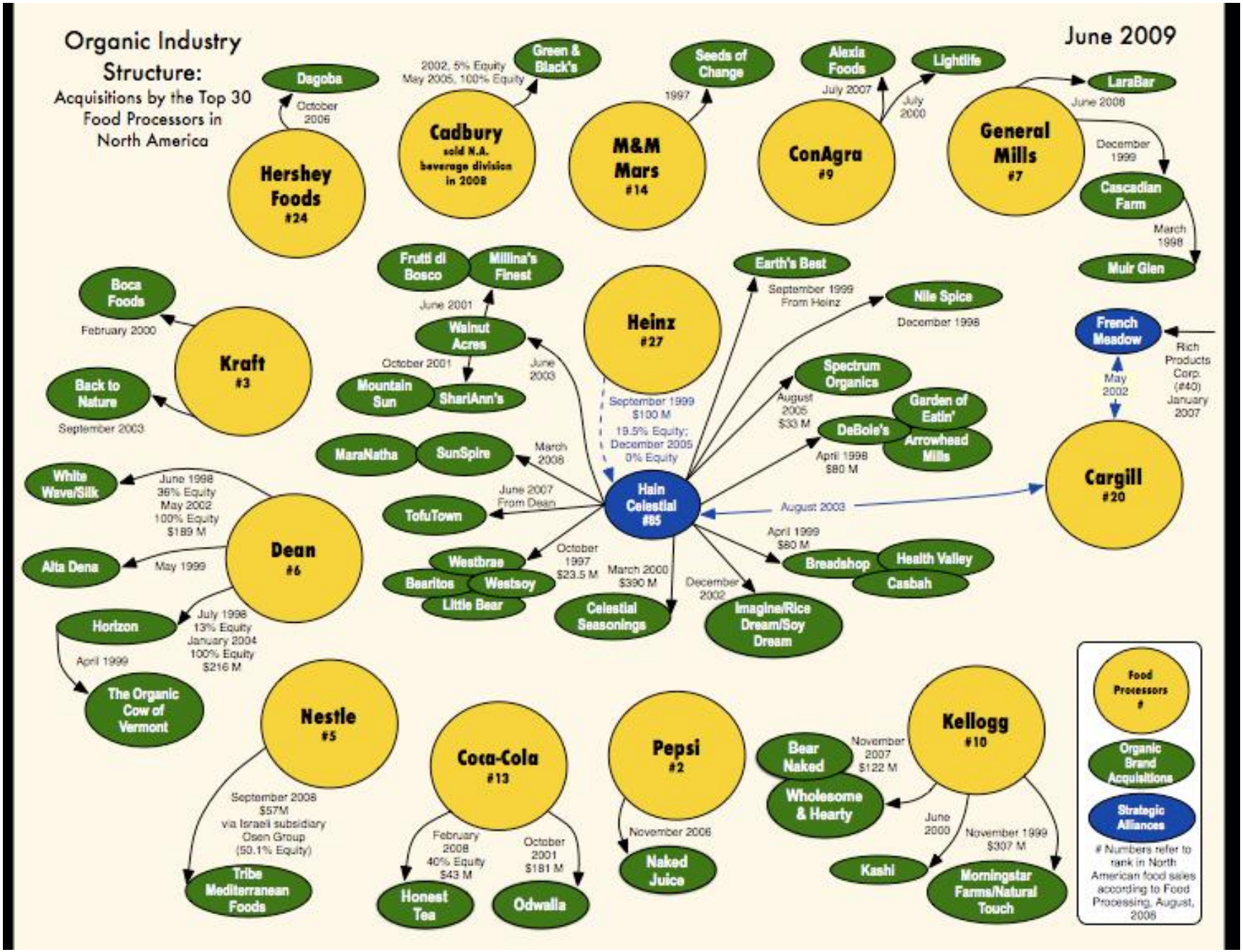


Swift & Company®

Smithfield®

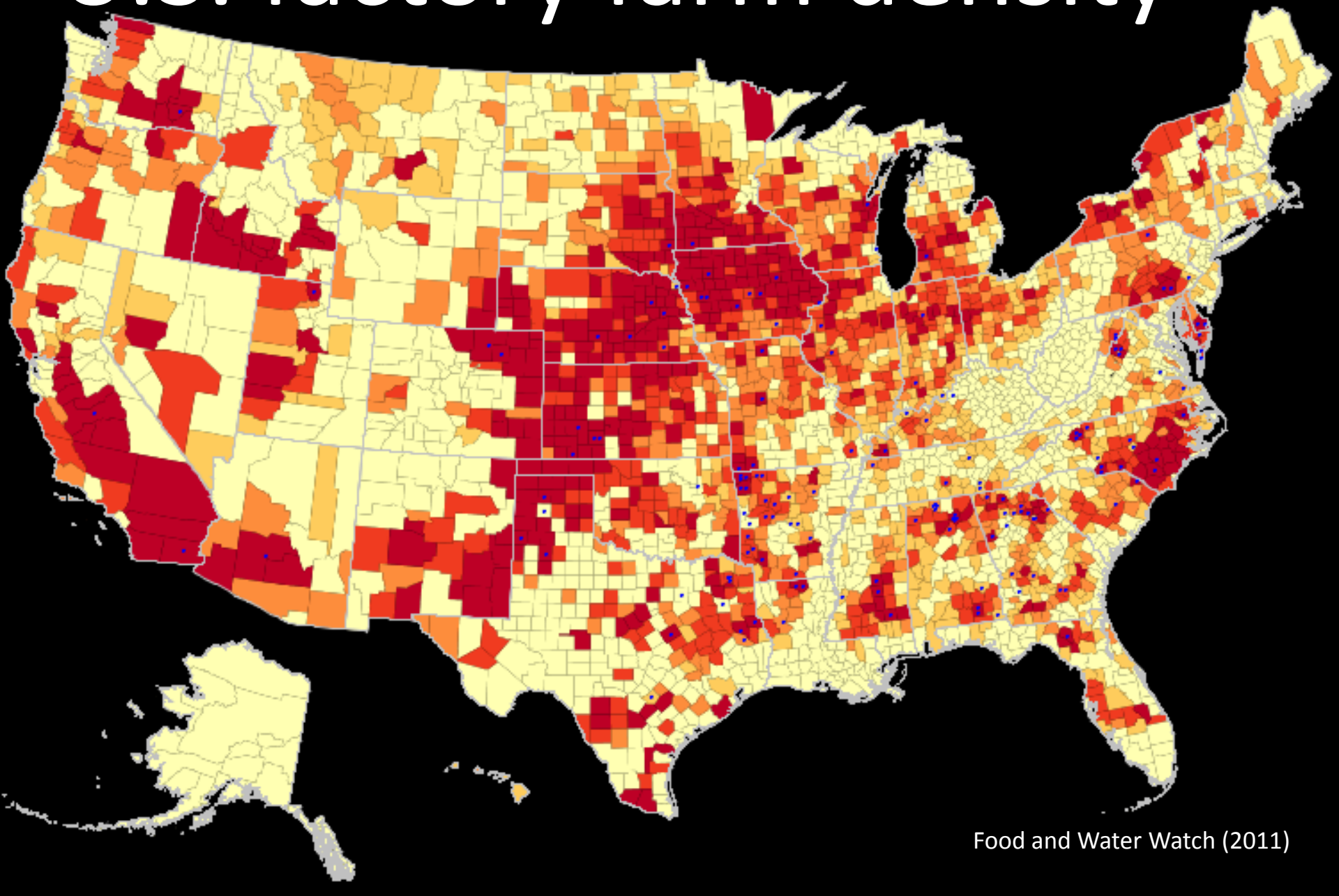

Seed Industry Structure
1996 - 2008
Monsanto
ChinaSeed
CNDK
FTSementes
Monsoy
AdvantaCanola
Western
Peotec
DeltaPineLand
SyngentaGlobalCottonDivision
Petoseed (1995)
Bruinsma (1994)
Genecorp (1994)
Hungnong
Seminis
Barham
Horticeres
DeRuiter
Carnia
ISG
Calgene
Agracetus
ChoongAng
RoyalSluis (1995)
Agroceres
Asgrow
Marmot
EIDParryRallis
Holdens
Ciagro
CDMMandiyu
InterstateCanola
Renessen
Cargill
Ayala
PBIC
Ecogen
Poloni
Terrazawa
DeKalbAyala
DeKalb (1995)
Cargill Intl.SeedDivision
CustomFarmSeed
JacobHartz (1995)
HybriTechEurope
Unilever
Sensako
Paras
CottonStates
HybriTech (1995)
PauEuralis
RhoBio
Daehnfeldt
EmergentGenetics
AgriProWheat
Agroeste
AlyParticipacoes
Biogemma
Indusem
LimagrainCanada
CornStatesIntl
Mahyco
FirstLine
Mahendra
CornStatesHybrid
SementesAgroceres
WilsonSeeds
ChannelBio
Diener
GoldCountry
MidwestSeedGenetics
Kruger
CornBelt
Crows
Trisler
MoweaquaSeeds
TrelaySeeds
SpecialtyHybrids
NCPlusHybrids
ASI
FieldersChoice
StewartSeeds
iCORN
HeartlandHybrids
Fontanelle
CampbellSeed
REA
NebraskaIrrigated
BoCa
LewisHybrids
Sieben
HubnerSeed
HeritageSeeds
StoneSeeds
Jung
Hawkeye
Thurston
ExSeed
SvalofWeibull
BASF
CropDesign
Nidera
Paragon
NideraSemillas
Nunhems (1995)
SeedEx
RioColorado
CottonSeedIntl
Gustafson
LeenDeMos
Nunza (1986)
RelianceGenetics
PGS
AgrEvoCotton
AssocFarmersDelinting
Hoechst
Proagro
Bayer
CaliforniaPlantingCotton
Granja4Irmaos
Schering
GermainsCotton
Aventis
AgrEvo
GeneXSorghum
Stoneville
HelenaCotton
SementesRibeiral
HollandCottonseed
MitlaPesquisa
BrownfieldSeedDelinting
PlanTecBiotech
Sunseeds
SementesFartura
RhonePoulenc
(1995)
CPBTwyford
Wensman
KWS
Agreliant
LochowPetkus (1967)
ProducersHybrids
CarlSperling
AustralianGrainTech
Clause
Hazera
Kyowa
Swaghat
Limagrain
AdvantaEUVegetable
YuanLongping
BioSeeds
CeeKay
Innoseeds
HarrisMoran
Westhove
VandenBerg
Avesthagen
Cenex
ABIAlfalfa
Hytest
CenexHarvest
Land O'Lakes
Agriliance
HarvestStates
SOYGENETICS
FarmlandIndustries
SpecialtyGrains
FFRCoop
CooperativeBusinessIntl
EridaniaBeghinSay
Goldsmith
InterstatePayco
Gutwein
ConradFafard
SPS
KoipesolAgrosemAgra
Garst
PSAGenetics
AdvantaNACornSoybeans
ResourceSeeds
AgriPro
NorthrupKing
CibaGeigy
Fischer
DiaEngei
Maisadour
Novartis
Syngenta
AWB
LongReach
Agritrading
Sandoz
SturdyGrow
Zimmerman
AstraZeneca
GoldenHarvest
Zeneca
Mogen
Astra
ZeraimGedera
Sanbei
GreenLeafGenetics
Hybrinova
Verdia
ProteinTech. Int.
DuPont
DoisMarcos
Sunseeds
Pioneer
OptimumQualityGrains
CurrySeed
ShandongDenghaiPioneer
DunhuangPioneer
Denghai
Dunhuang
Triumph
VerneuilHolding
DairylandSeed
Sudwestsaat
BiogeneticaDeMilho
Brodbeck
AdvancedAgriTraits
HibridosColorado
UnitedAgriseeds
Dow
IllinoisFoundation
Mycogen
CargillNorthAmerica
Agromen
MTI
DuoMaize
Morgan
DinamilhoCarol
EmpresaBrasileira
BioPlantResearch
Phytogen
RenzeHybrids
JGBoswell
Seed Companies
Pharmaceutical/Chemical Companies
Other Companies
Full Ownership
Partial Ownership
Size proportional to global seed market share
Phil Howard, Assistant Professor, Michigan State University
http://www.msu.edu/~howardp

Howard (2009)


Organic Industry Structure:
Acquisitions by the Top 30 Food Processors in North America
June 2009
Hershey Foods #24
Dagoba
October 2006
Cadbury
sold N.A. beverage division in 2008
2002, 5% Equity
May 2005, 100% Equity
Green & Black's
M&M Mars #14
1997
Seeds of Change
ConAgra #9
July 2007
Alexia Foods
July 2000
Lightlife
General Mills #7
LaraBar
June 2008
December 1999
Cascadian Farm
March 1998
Muir Glen
Heinz #27
Frutti di Bosco
Millina's Finest
June 2001
Walnut Acres
October 2001
Mountain Sun
SharlAnn's
June 2003
Boca Foods
February 2000
Kraft #3
Back to Nature
September 2003
MaraNatha
SunSpire
March 2006
Hain Celestial #85
September 1999
$100 M
19.5% Equity;
December 2005
0% Equity
Earth's Best
September 1999
From Heinz
Nile Spice
December 1998
Spectrum Organics
August 2005
$33 M
DeBole's
Garden of Eatin'
Arrowhead Mills
April 1998
$80 M
French Meadow
May 2002
Rich Products Corp. (#40)
January 2007
Cargill #20
August 2003
White Wave/Silk
June 1998
36% Equity
May 2002
100% Equity
$189 M
Dean #6
Alta Dena
May 1999
Horizon
July 1998
13% Equity
January 2004
100% Equity
$216 M
April 1999
The Organic Cow of Vermont
TofuTown
June 2007
From Dean
Westbrae
Bearitos
Westsoy
Little Bear
October 1997
$23.5 M
Celestial Seasonings
March 2000
$390 M
December 2002
Imagine/Rice Dream/Soy Dream
April 1999
$80 M
Breadshop
Health Valley
Casbah
Nestle #5
September 2008
$57M
via Israeli subsidiary
Osem Group
(50.1% Equity)
Tribe Mediterranean Foods
Coca-Cola #13
February 2008
40% Equity
$43 M
Honest Tea
October 2001
$181 M
Odwalla
Pepsi #2
November 2006
Naked Juice
Kellogg #10
Bear Naked
Wholesome & Hearty
November 2007
$122 M
June 2000
Kashi
November 1999
$307 M
Morningstar Farms/Natural Touch
Food Processors #
Organic Brand Acquisitions
Strategic Alliances
Numbers refer to rank in North American food sales according to Food Processing, August, 2008

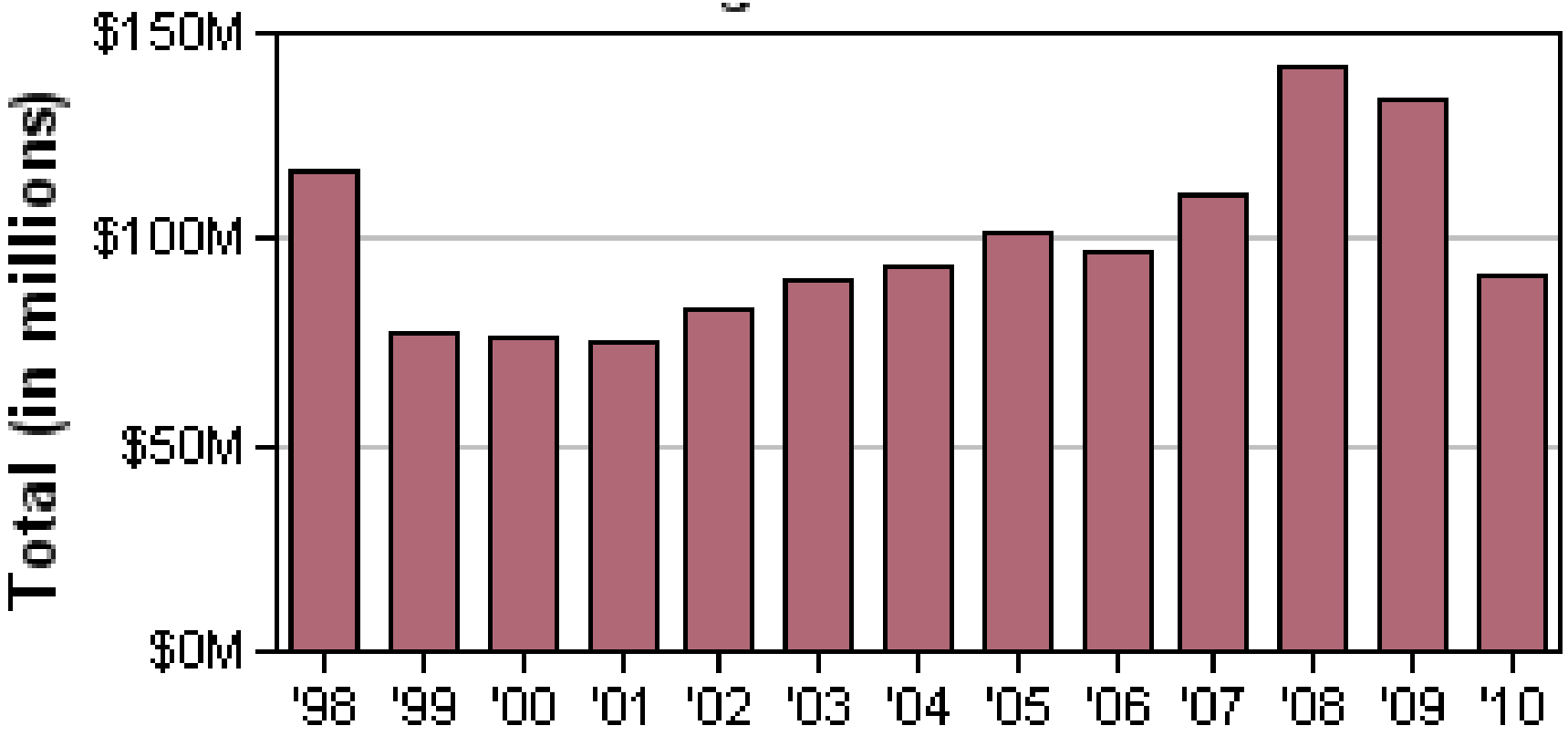
Howard (2009)

U.S. factory farm density



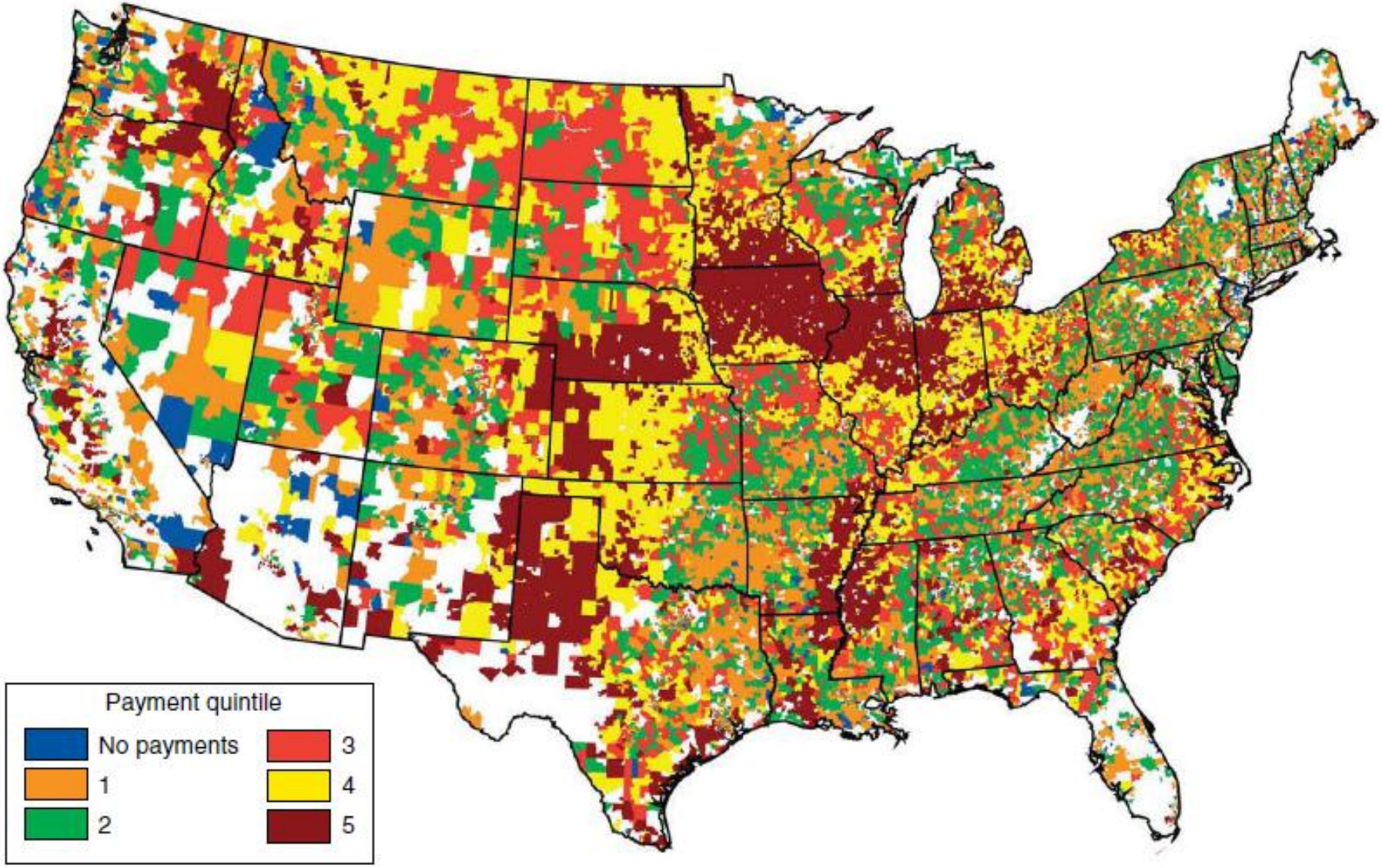
Food and Water Watch (2011)

Annual lobbying on agribusiness



Center for Responsive Politics

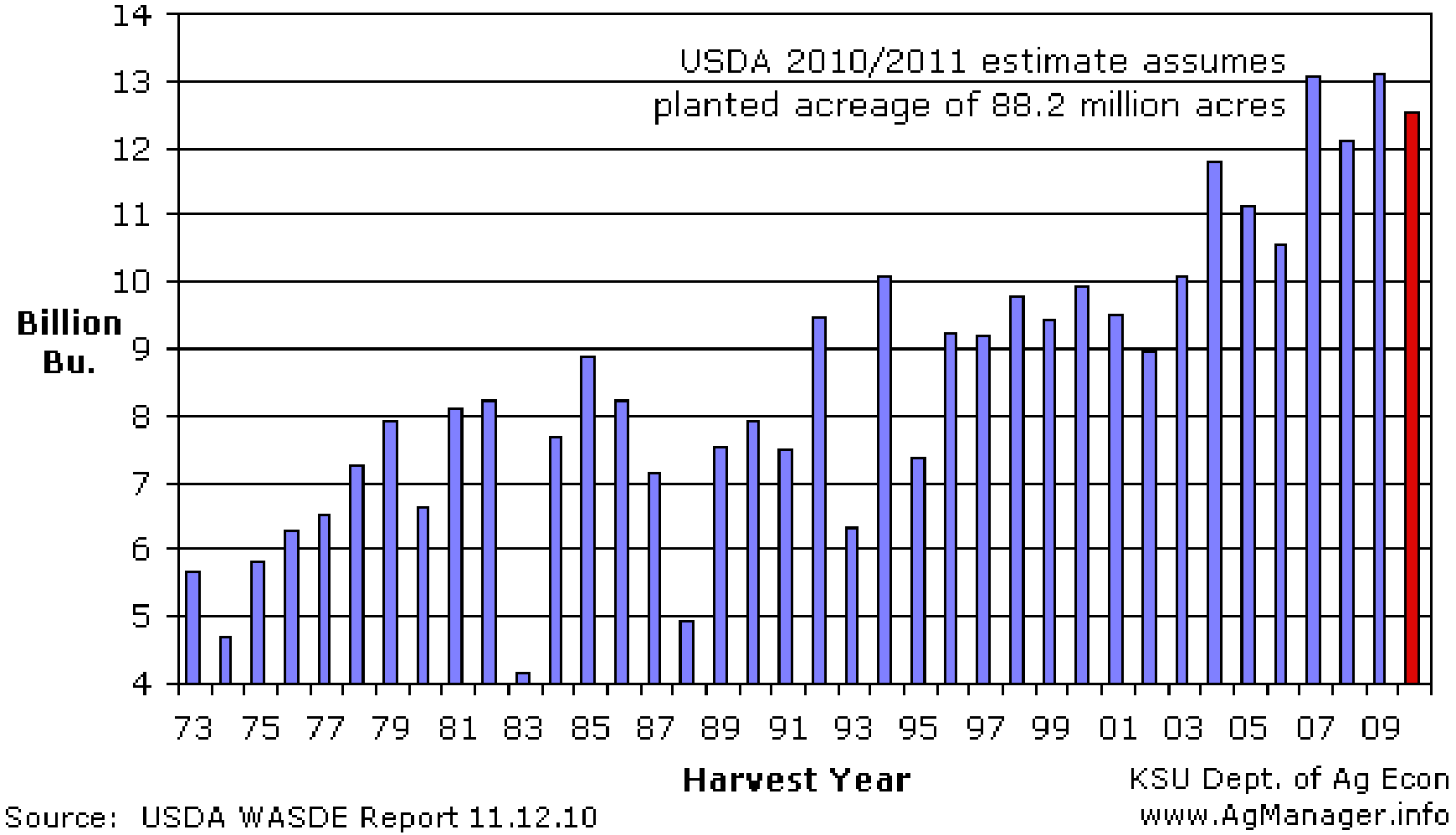
Mean payouts per crop acre



USDA (2007)

Price manipulation

Total U.S. corn production

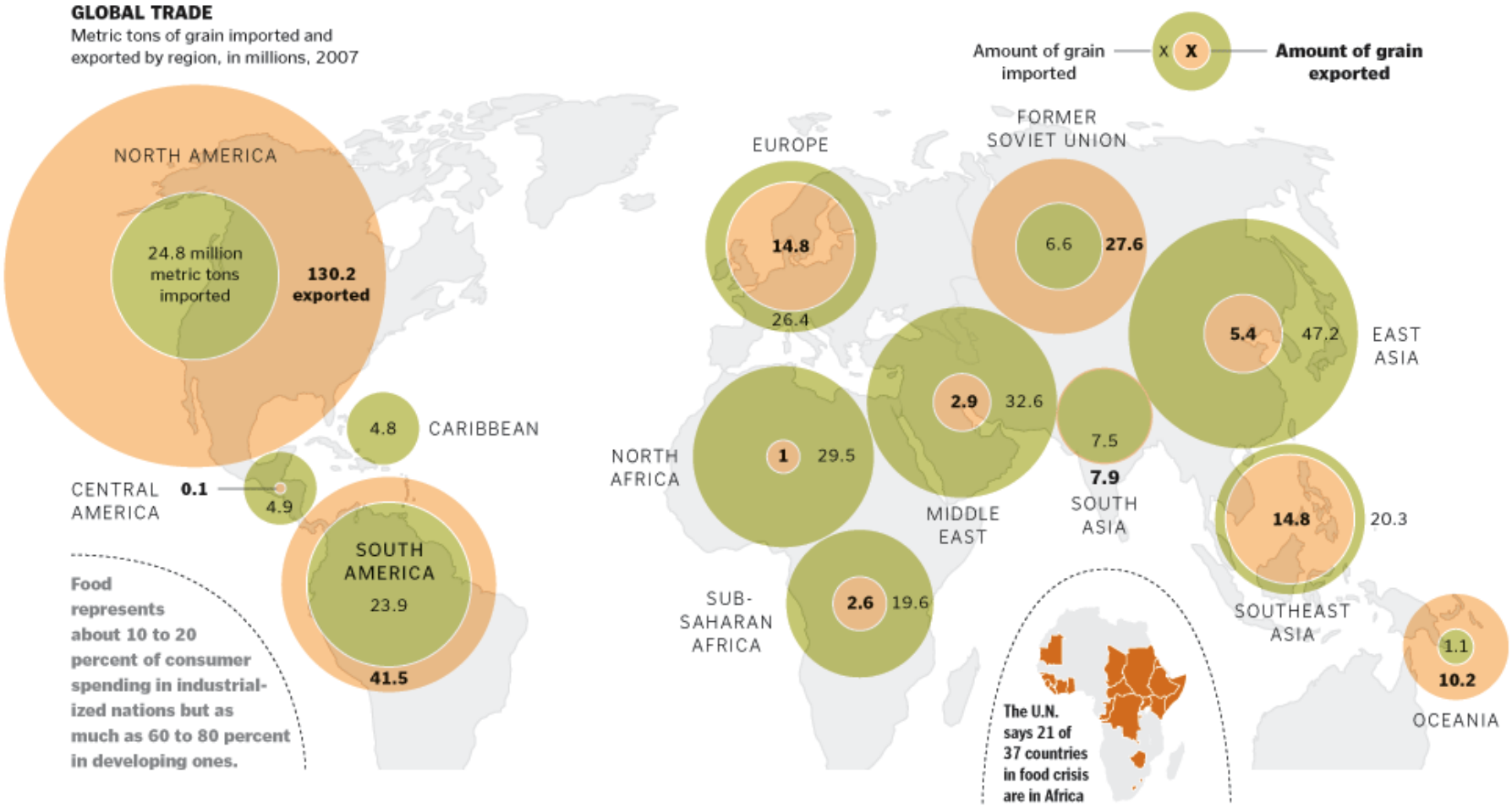


Source: USDA WASDE Report 11.12.10

KSU Dept. of Ag Econ
www.AgManager.info


CORN FLAKES
Kellogg's
CORN
FLAKES
ENRICHED
ENRICHIS
CANADA
SANDWICH
Pop-Tarts
Pop-Tarts
Bee Hive
CORN
TRUF
Nestlé
CRISPY
CRUNCH

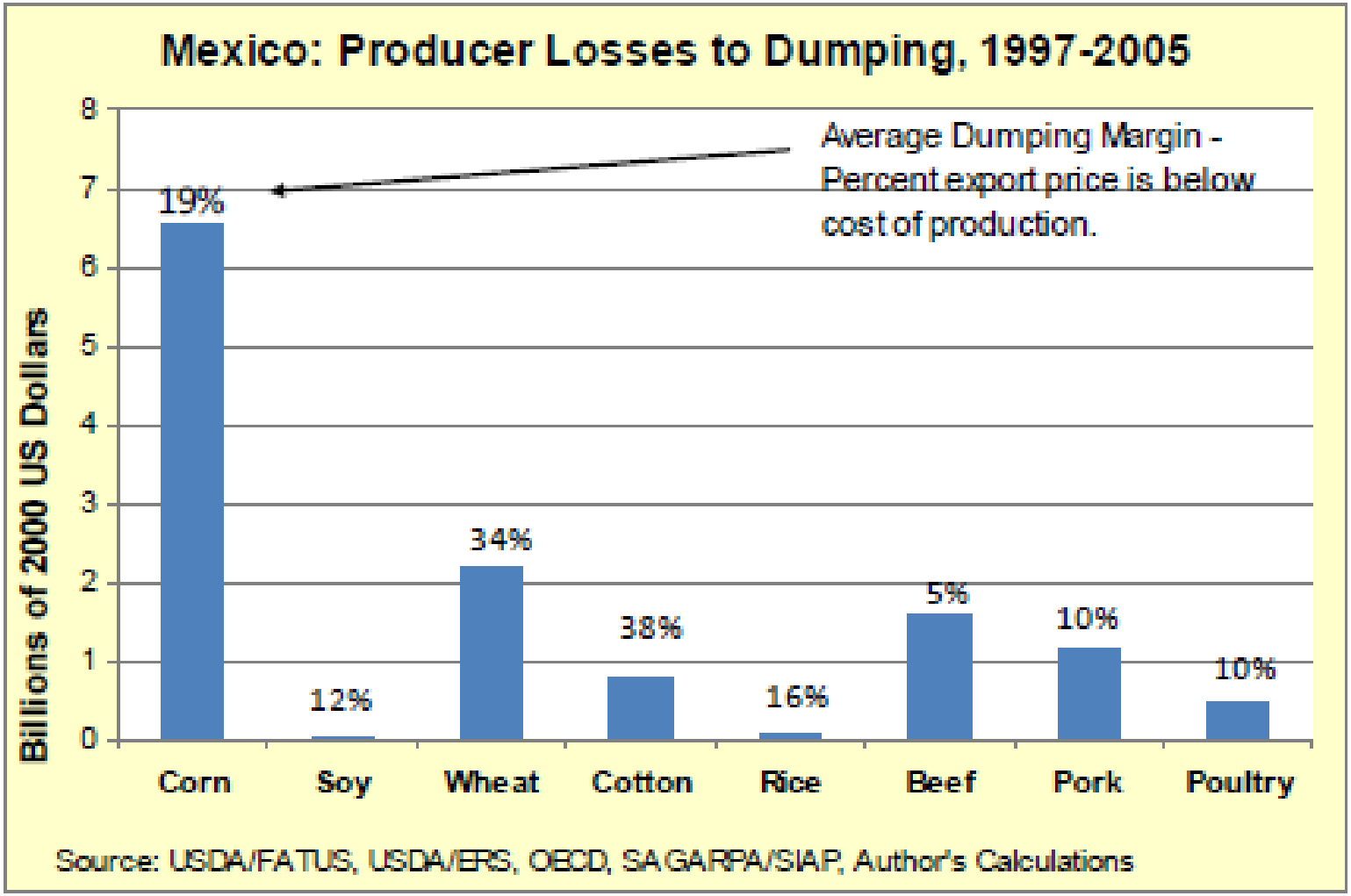
Grain imports/exports



SOURCES: Food and Agriculture Organization of the United Nations, World Bank, U.S. Department of Agriculture, Renewable Fuels Association, Food and Agricultural Policy Research Institute, Bloomberg, International Grains Council

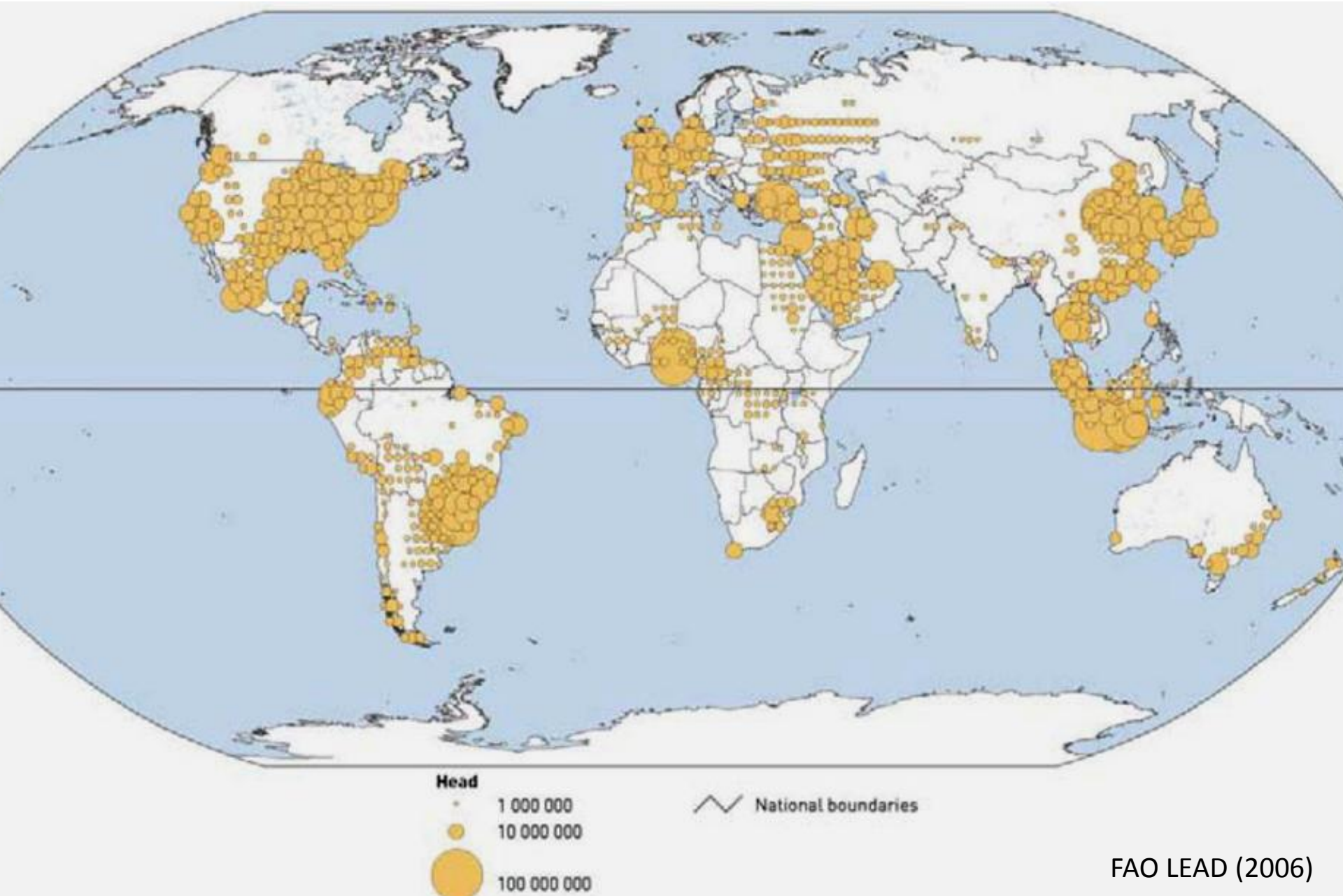
Food and Agriculture Organization, World Bank, USDA, Renewable Foods Association, Food and Agricultural Policy Research Institute, Bloomberg, International Grains Council

Grain dumping


Mexico: Producer Losses to Dumping, 1997-2005
Billions of 2000 US Dollars
0
1
2
3
4
5
6
7
8
Average Dumping Margin - Percent export price is below cost of production.
19%
12%
34%
38%
16%
5%
10%
10%
Corn
Soy
Wheat
Cotton
Rice
Beef
Pork
Poultry
Source: USDA/FATUS, USDA/ERS, OECD, SAGARPA/SIAP, Author's Calculations

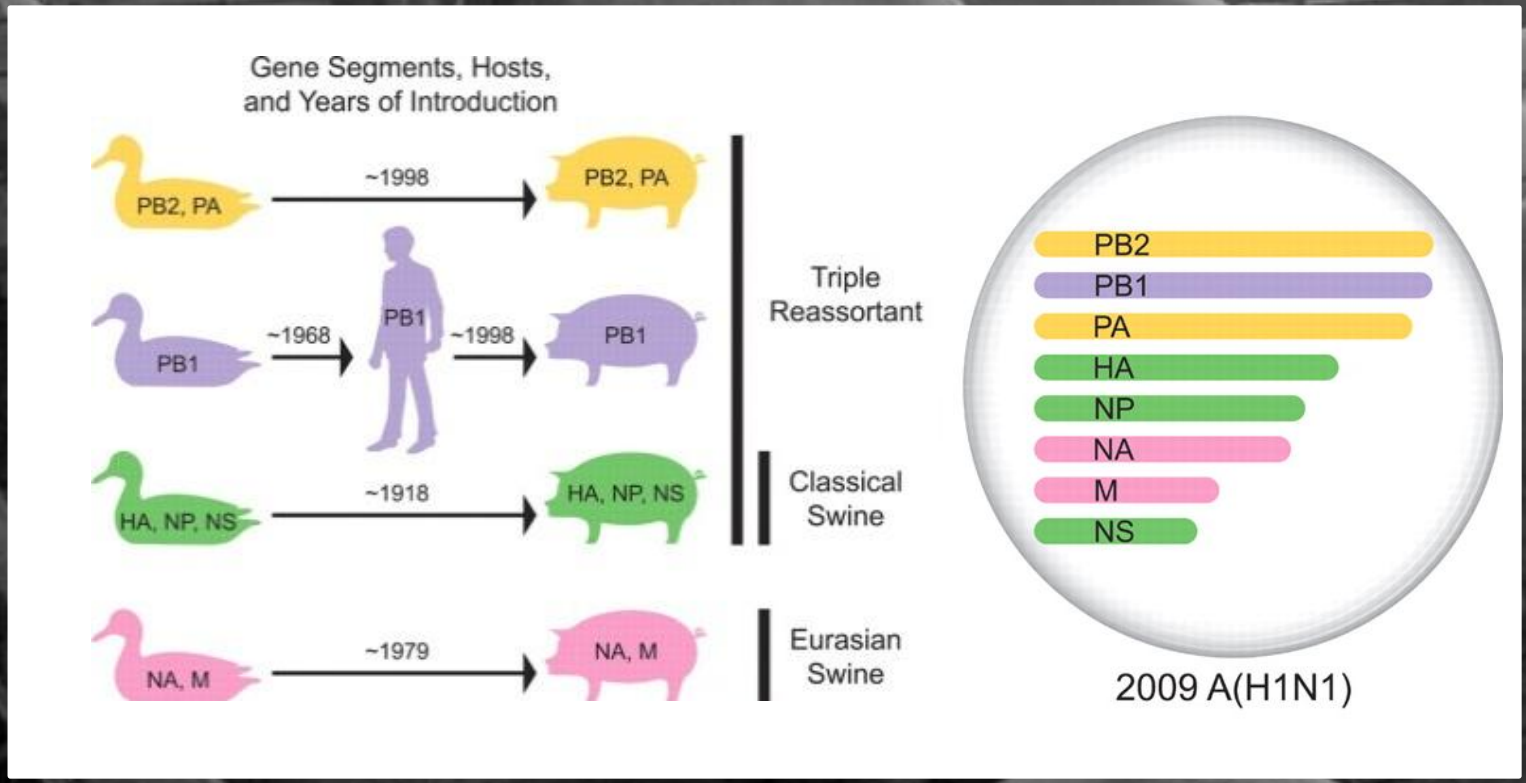
Wise (2009)

Estimated industrially produced poultry



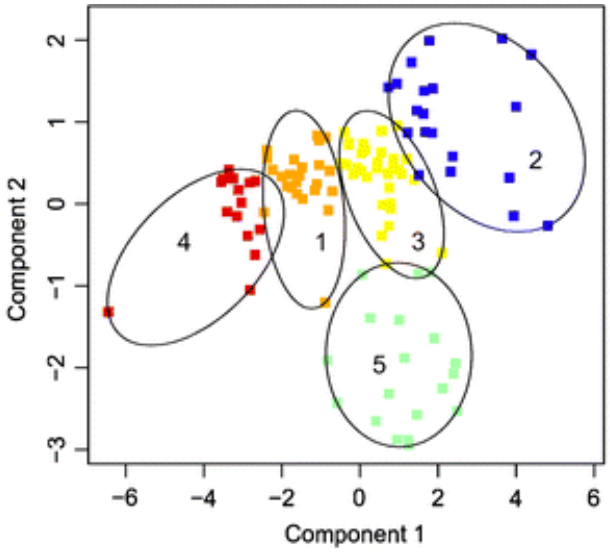
FAO LEAD (2006)

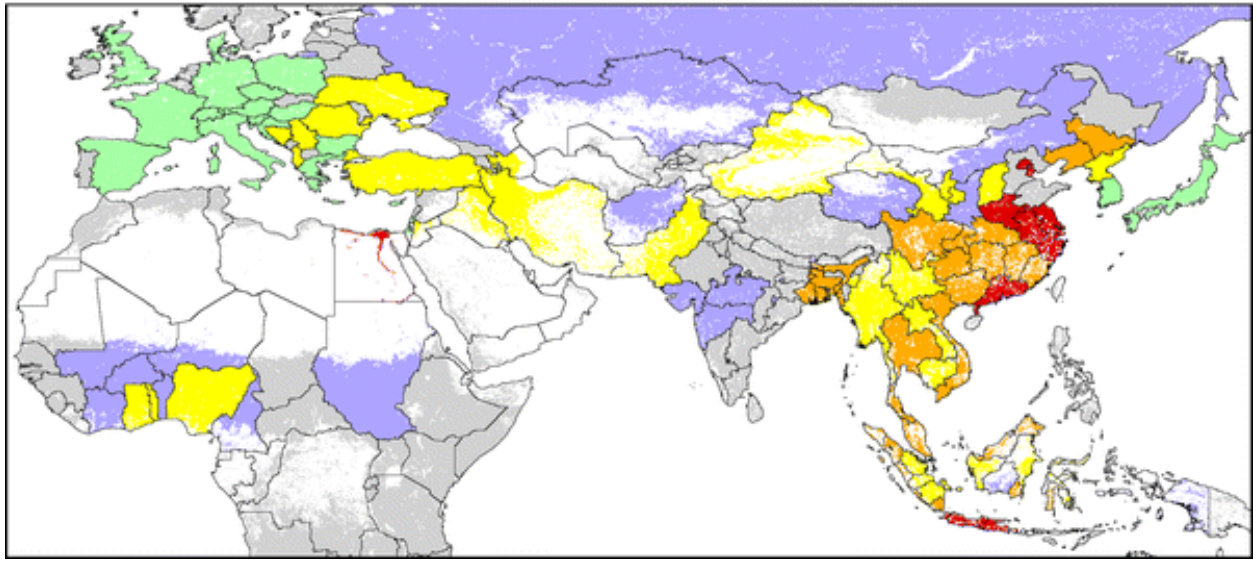
The genomic tell-tale
Multi-continental reassortment



Garten *et al*. (2009)

Agroecological niches





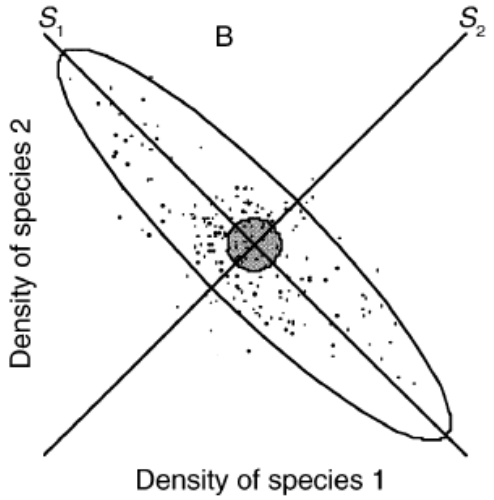
Hogerwerf *et al.* (2010)

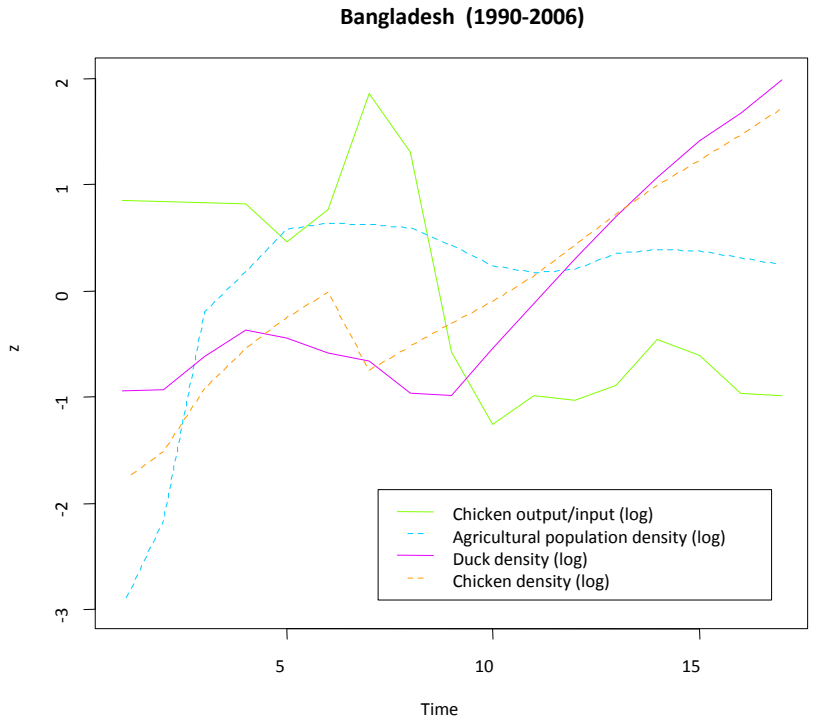
Agroecological resilience

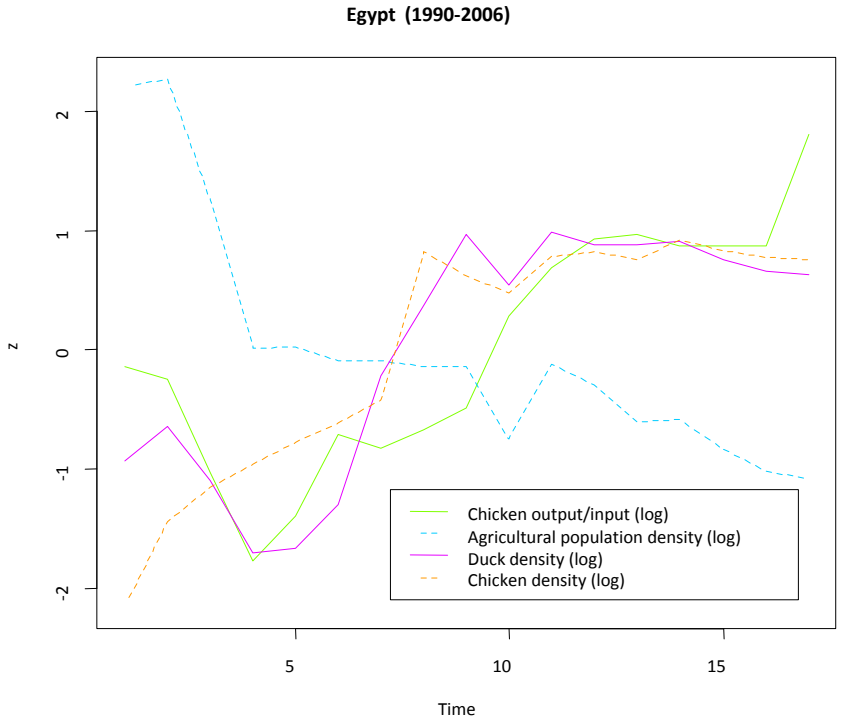
First-order multivariate autoregression (MAR(1)) model

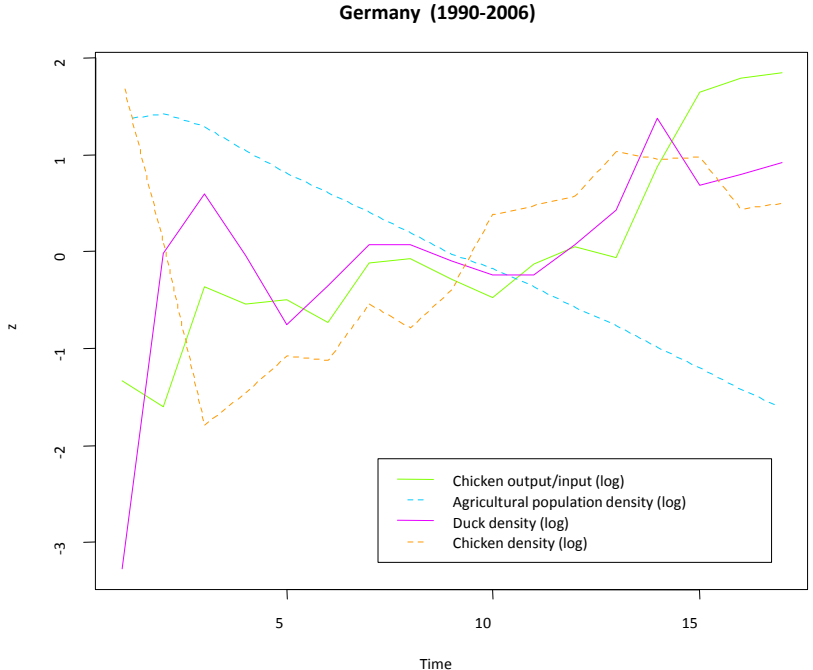
$$x_i(t+1) = b_{i,0} + b_{i,1}x_1(t) + b_{i,2}x_2(t) + \ldots + b_{i,S}x_S(t) + \varepsilon_i(t, x_1(t), \ldots, x_S(t))$$

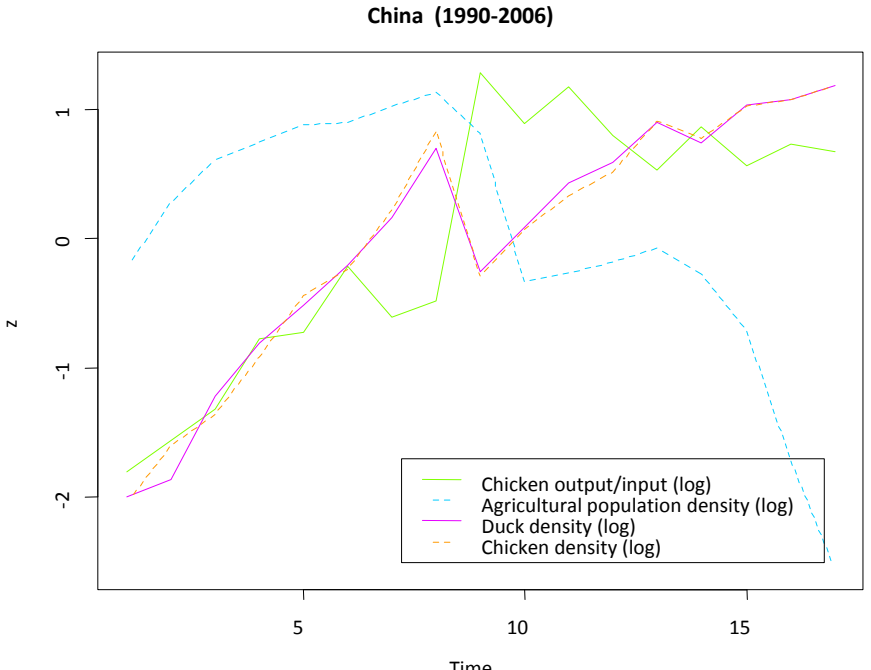
$$\mathbf{X}_t = \mathbf{A} + \mathbf{B}\mathbf{X}_{t-1} + \mathbf{E}_t,$$




Bangladesh (1990-2006)
z
Time
Chicken output/input (log)
Agricultural population density (log)
Duck density (log)
Chicken density (log)


Egypt (1990-2006)
z
Time
Chicken output/input (log)
Agricultural population density (log)
Duck density (log)
Chicken density (log)

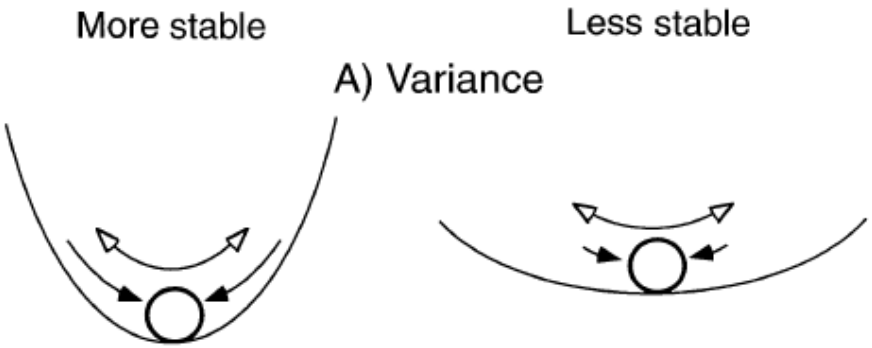

Germany (1990-2006)
z
Time
Chicken output/input (log)
Agricultural population density (log)
Duck density (log)
Chicken density (log)


China (1990-2006)
z
Time
Chicken output/input (log)
Agricultural population density (log)
Duck density (log)
Chicken density (log)

Variance

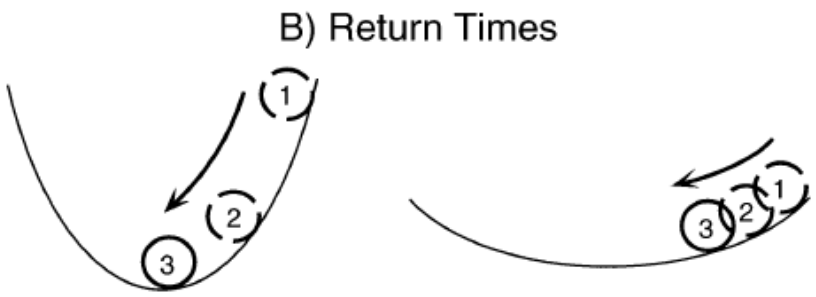
$$v_{\infty} = \psi^2 \, / \, (1 - \lambda^2)$$

$$\det(\mathbf{B})^2 = \det(\mathbf{V}_{\infty} - \mathbf{S}) \, / \, \det(\mathbf{V}_{\infty})$$



Return times

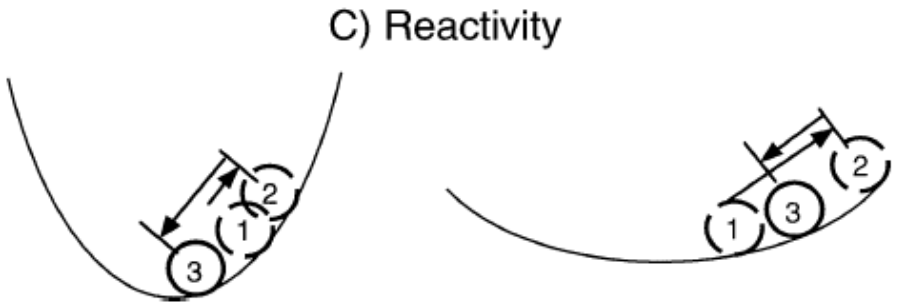
$$\boldsymbol{\mu}_t = \boldsymbol{\mu}_\infty + \mathbf{B}^t(\mathbf{x}_0 - \boldsymbol{\mu}_\infty) \longrightarrow \boldsymbol{\mu}_\infty = (\mathbf{I} - \mathbf{B})^{-1}\mathbf{A}$$

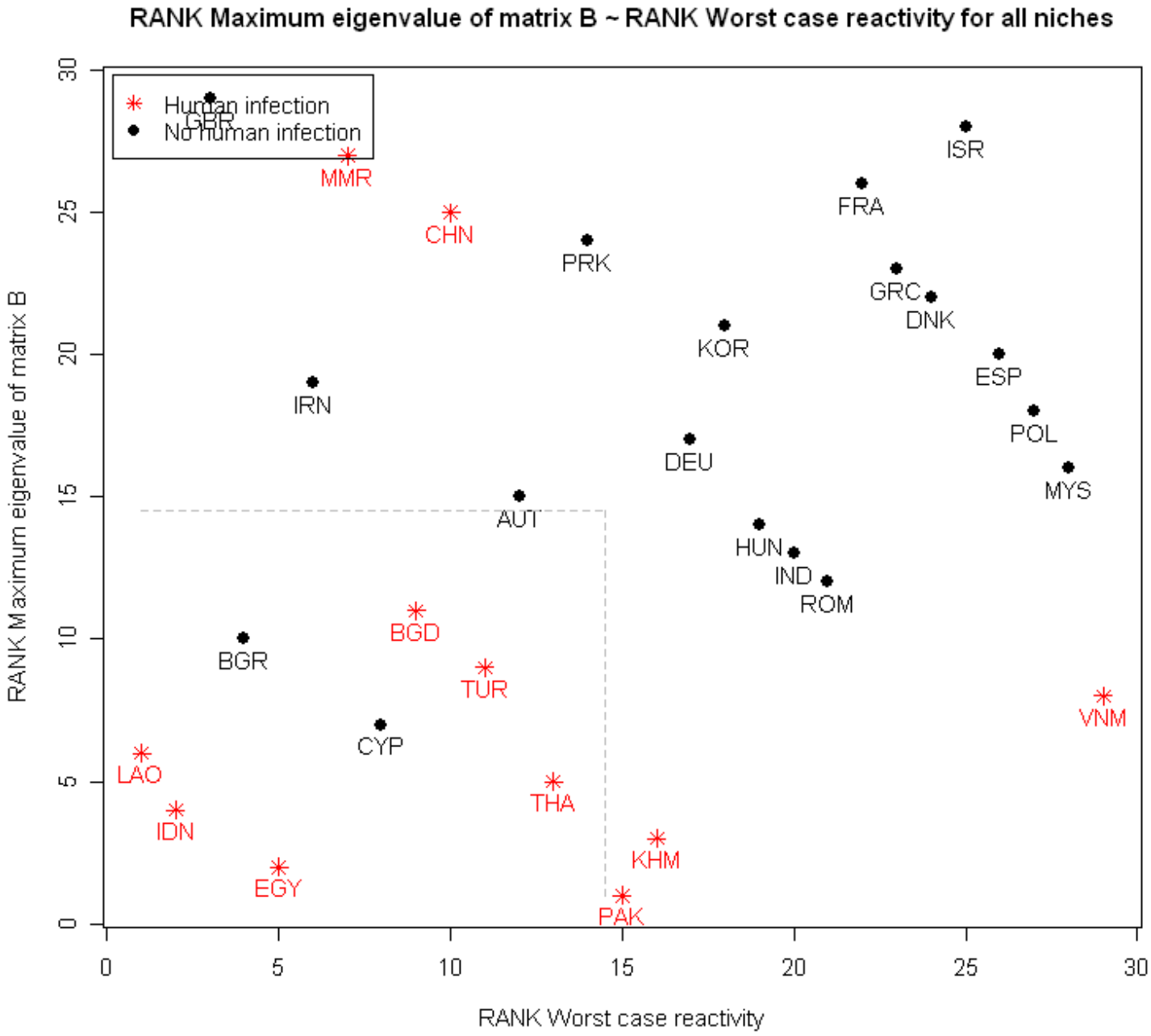


Reactivity

$$= - \mathrm{tr}[\boldsymbol{\Sigma}] \; / \; \mathrm{tr}[\mathbf{V}_{\infty}]$$

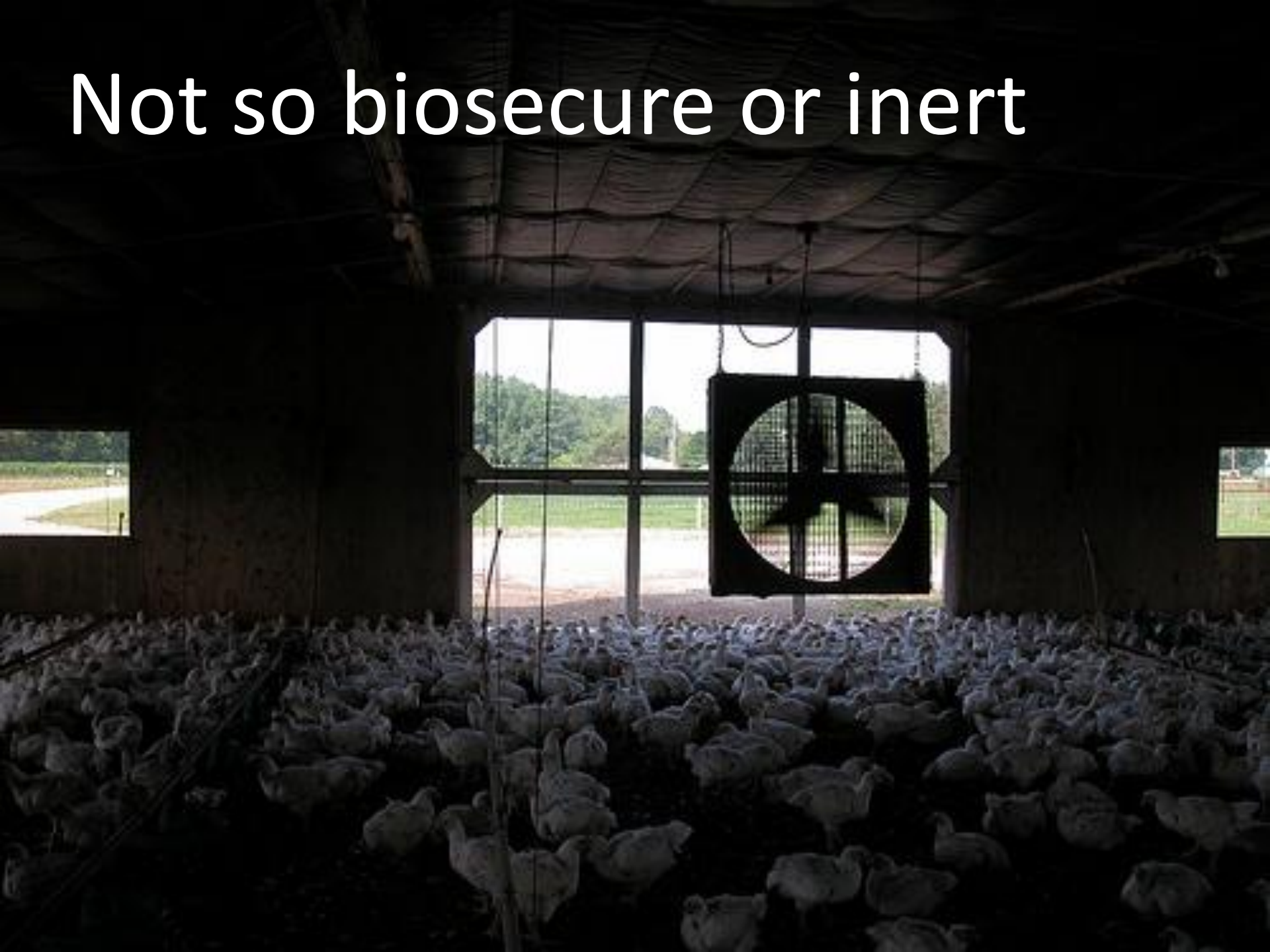
$$\leq \max(\lambda_{\mathbf{B'B}}) - 1$$

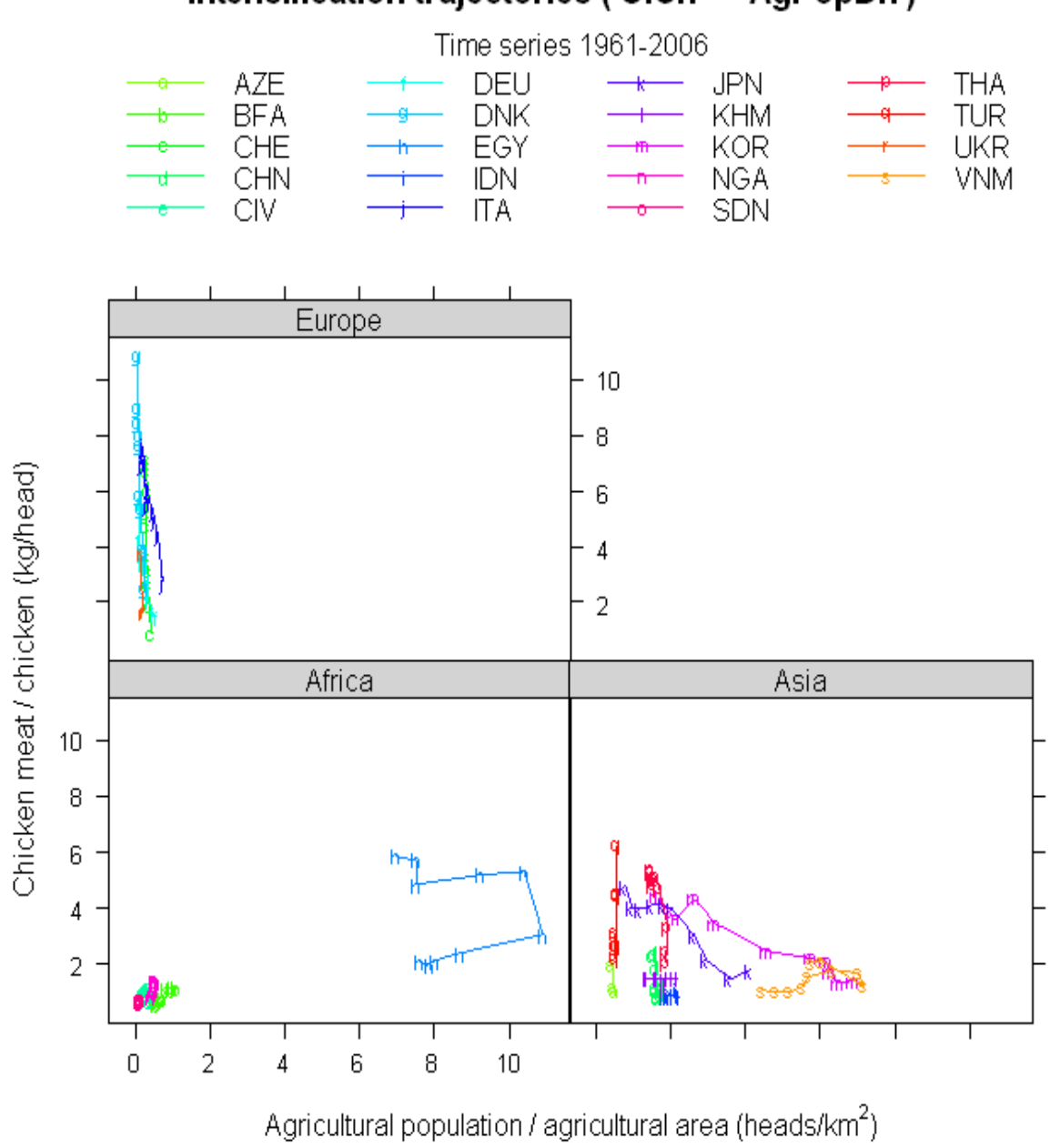




Hogerwerf *et al.* submitted

Not so biosecure or inert

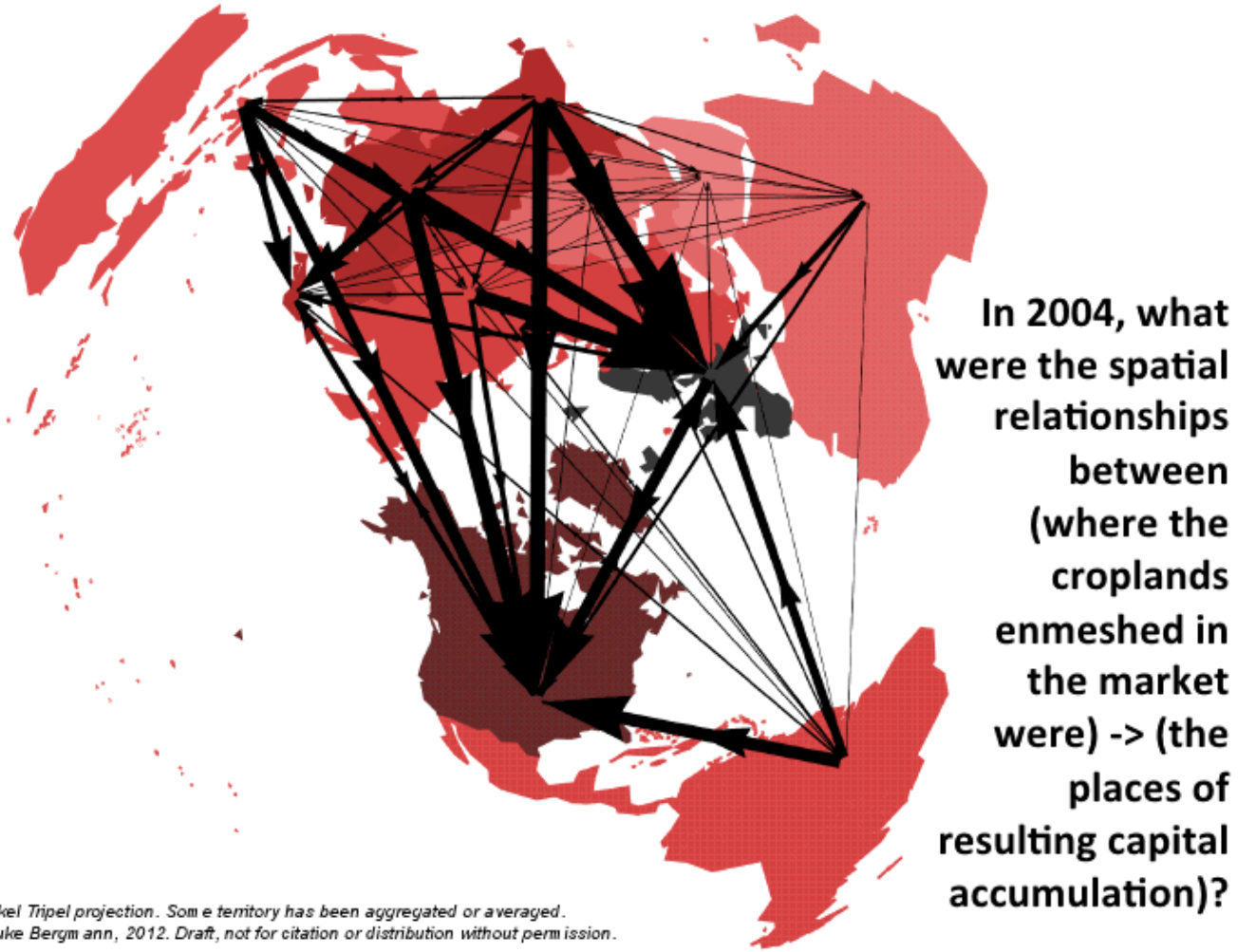



Intensification trajectories (OlCh ~ AgPopDn)
Time series 1961-2006
AZE
BFA
CHE
CHN
CIV
DEU
DNK
EGY
IDN
ITA
JPN
KHM
KOR
NGA
SDN
THA
TUR
UKR
VNM
Europe
Africa
Asia
Chicken meat / chicken (kg/head)
Agricultural population / agricultural area (heads/km2)
0
2
4
6
8
10

Periurban composites


Biomass (Tons)
1,200,000,000
1,000,000,000
800,000,000
600,000,000
400,000,000
200,000,000
-
People
Livestock
Wildlife

Circuits of capital

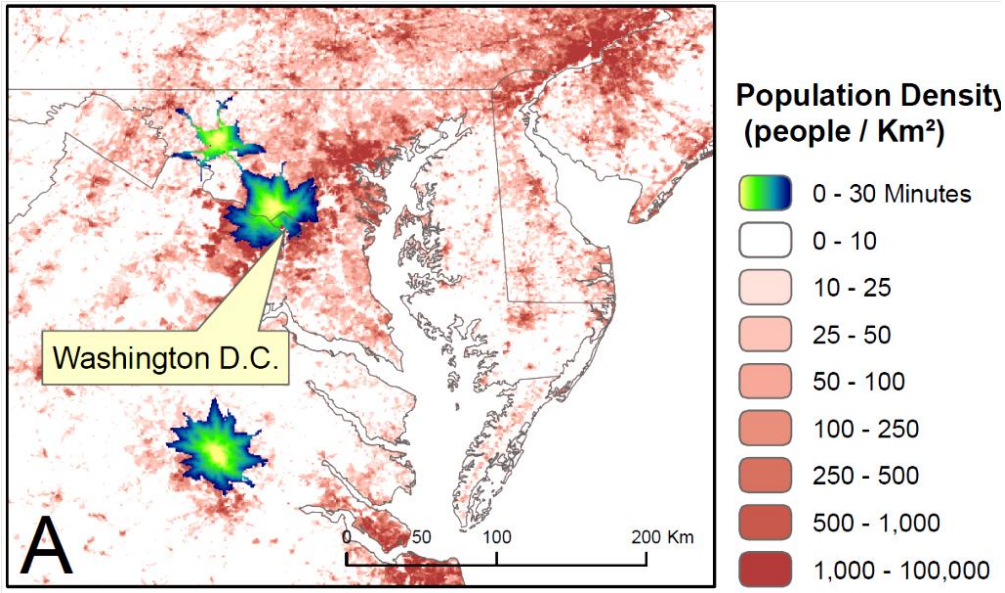


Bergmann (2012)

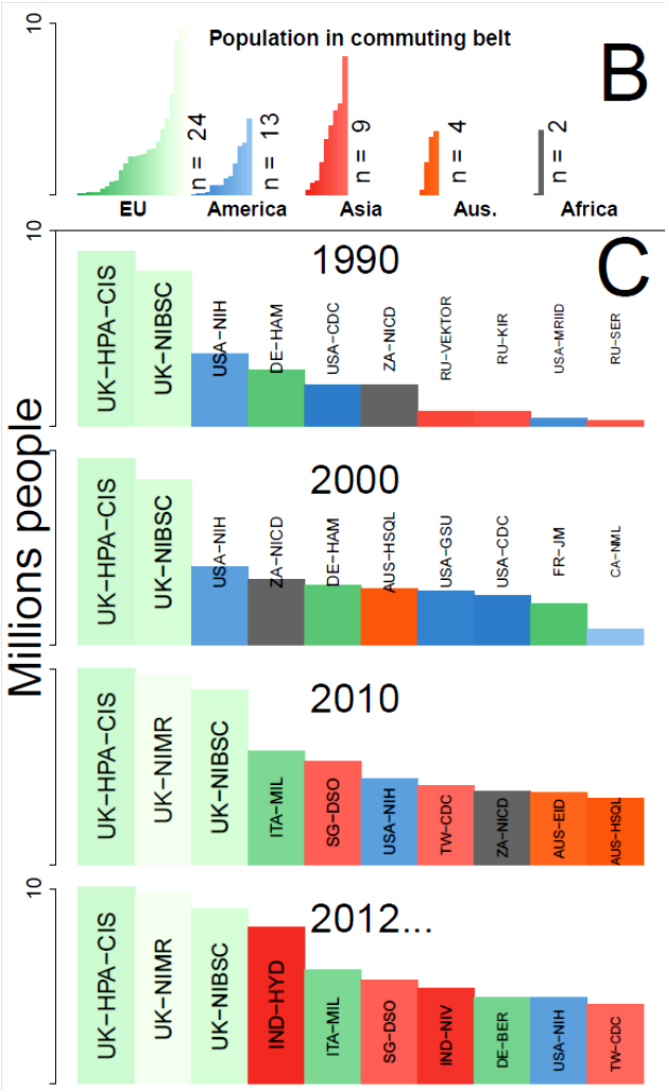
Hispanic population change in Iowa: 1990-2000

Source: Applied Pop. Lab, UW-Madison

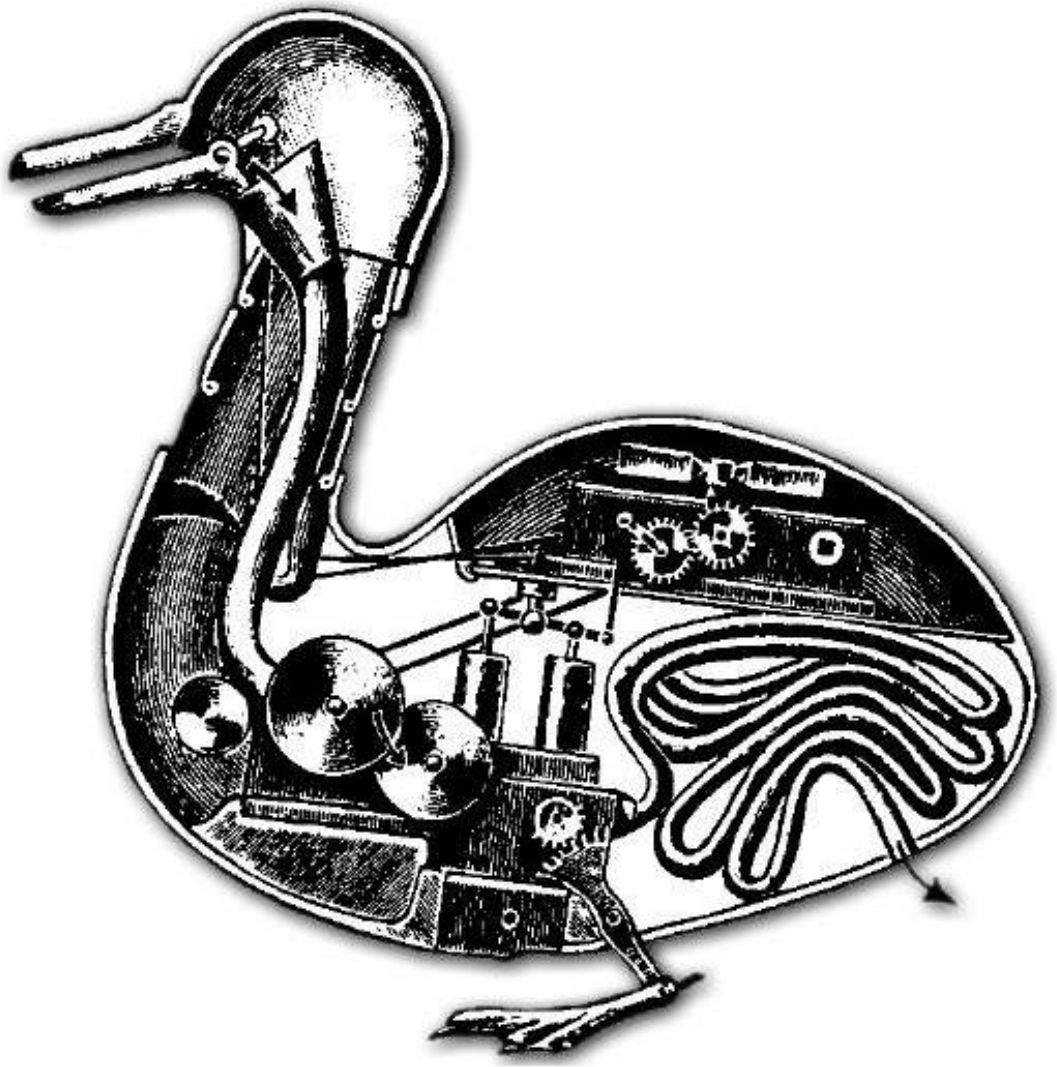
BSL-4 labs in urban centers



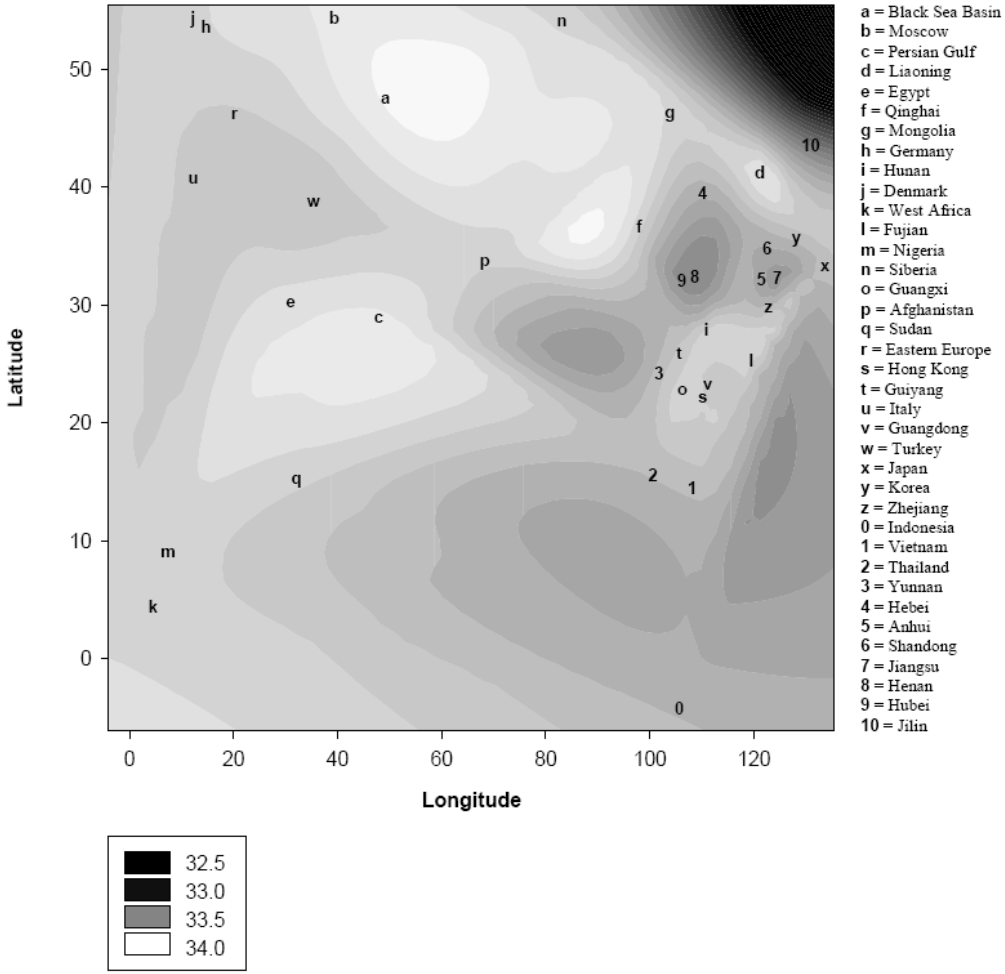
Van Boeckel *et al* (in press)

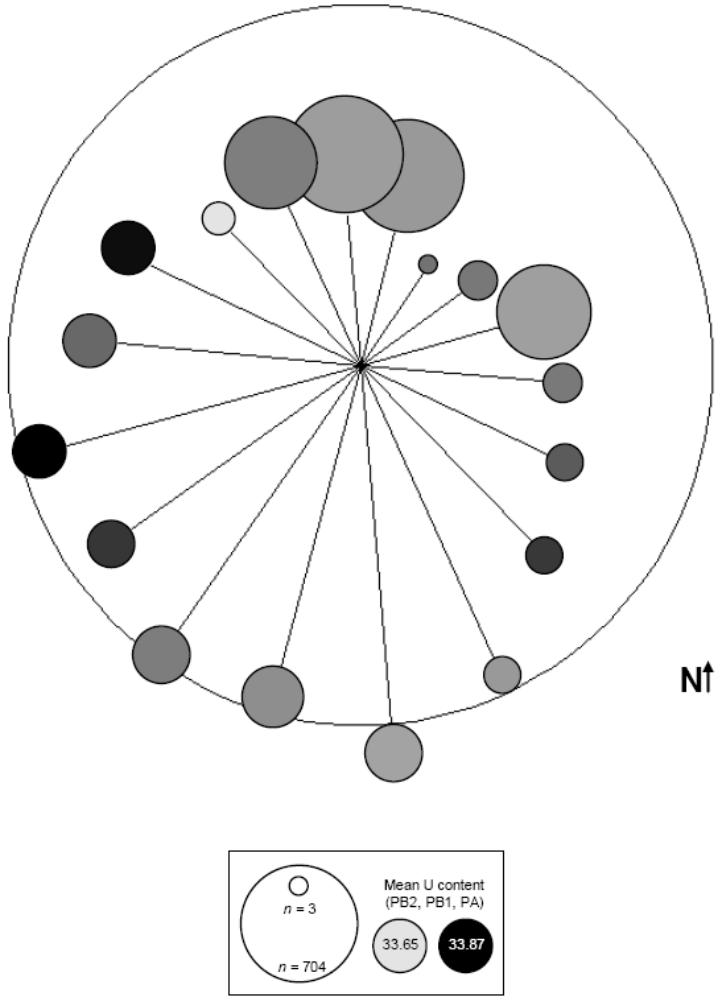


Reductionist epizoology



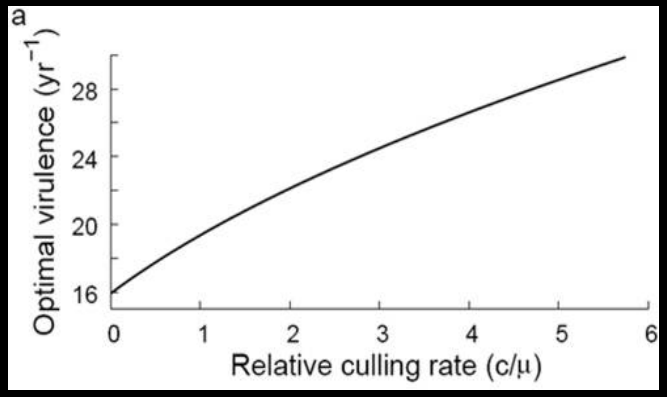
Anistropy undermines factorial design

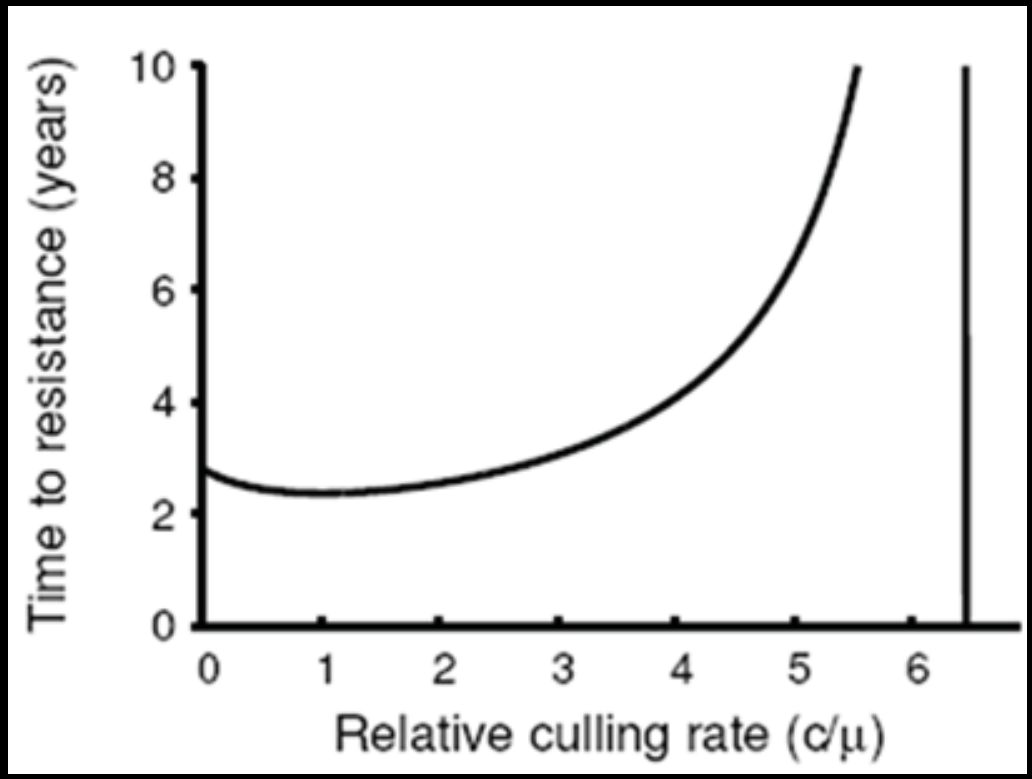




Wallace and Stern submitted

Virulence and resistance post-culling





Shim and Galvani (2009)

Worse as no actual reproduction in the field

EW GROUP

HENDRIX GENETICS

Farmer Maxwell's demon

Source: Ilaria Capua, Istituto Zooprofilattico Sperimentale delle Venezie

Thank you

Some of the work described today was supported by the Food and Agriculture Organization and the National Institutes of Health. The opinions expressed, however, are the presenter's alone.