Global Environmental Change and Land Use Change in Peri-Urban Areas
Taipei, Taiwan

29 November – 2 December 2008

The environmental impact of meat consumption in New York and Tokyo

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Outline of talk

- Background: The environmental impacts of meat consumption
- Introduction: Global and national trends in meat production, consumption and distribution
- Methods: Research questions, data and analyses
- Findings: The impact of meat consumption in NYC and Tokyo
- Conclusions and recommendations

Background: The environmental impacts of meat consumption

Background: The environmental impact of meat consumption

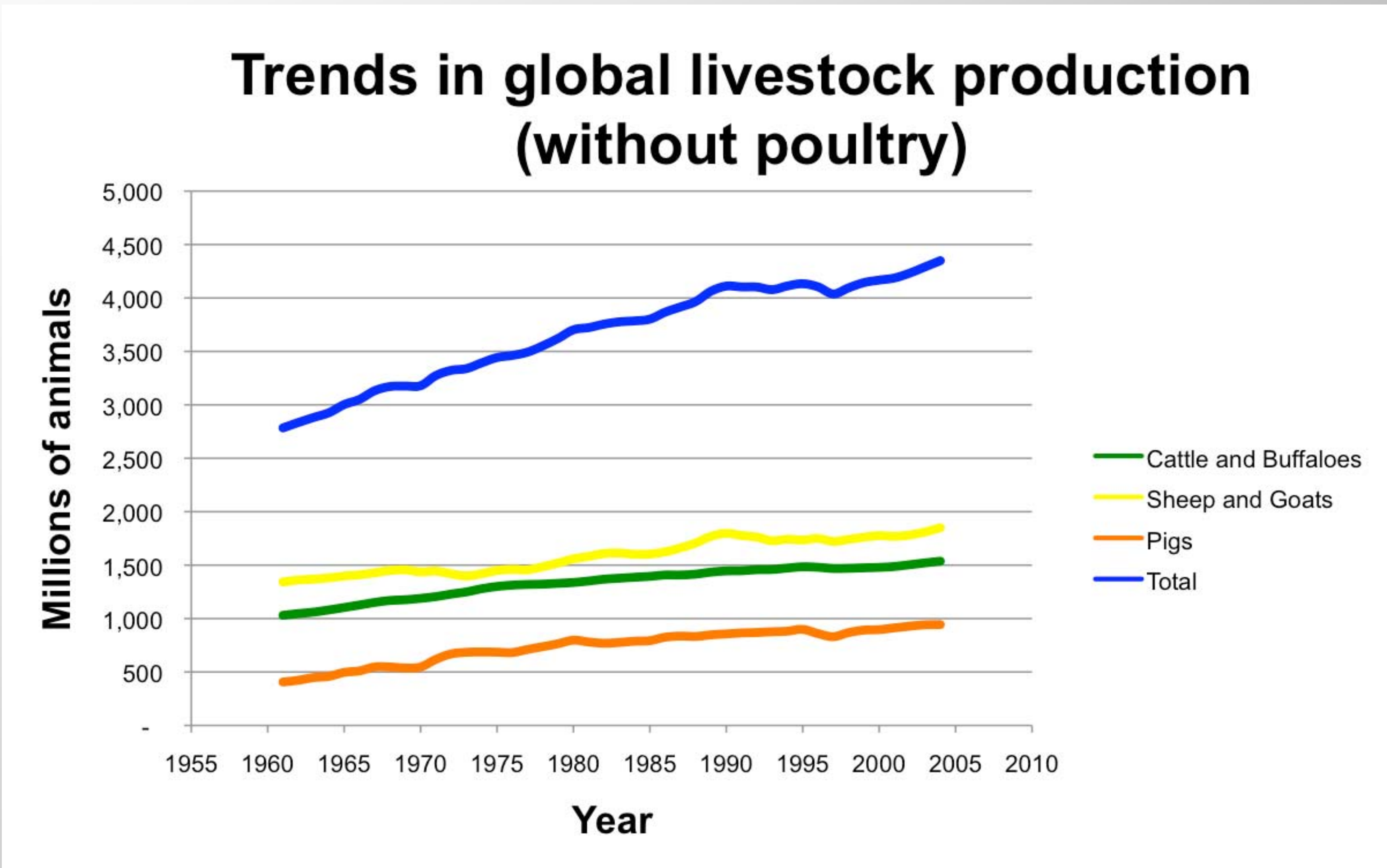
- Growth in livestock production and meat consumption contributes to a number of different environmental issues
  - Land use and degradation
  - Pollution and depletion of water
  - GHG emissions
  - Changes in global and local biogeochemical cycles
  - Cascading impacts on biodiversity

Background: The social impact of meat consumption

- Livestock production is important for the social sub-system!
  - Provides approximately one-third (2.2 billion) of humanity’s protein intake;
  - Provides approximately 40% of agricultural GDP;
  - Includes approximately 1.3 billion jobs and 1 billion livelihoods for the world’s poor
  - Livestock and meat consumption also have affects on health (cholesterol, obesity, zoonotic diseases, etc)

Introduction: Global meat production, consumption and distribution

Trends in livestock production globally



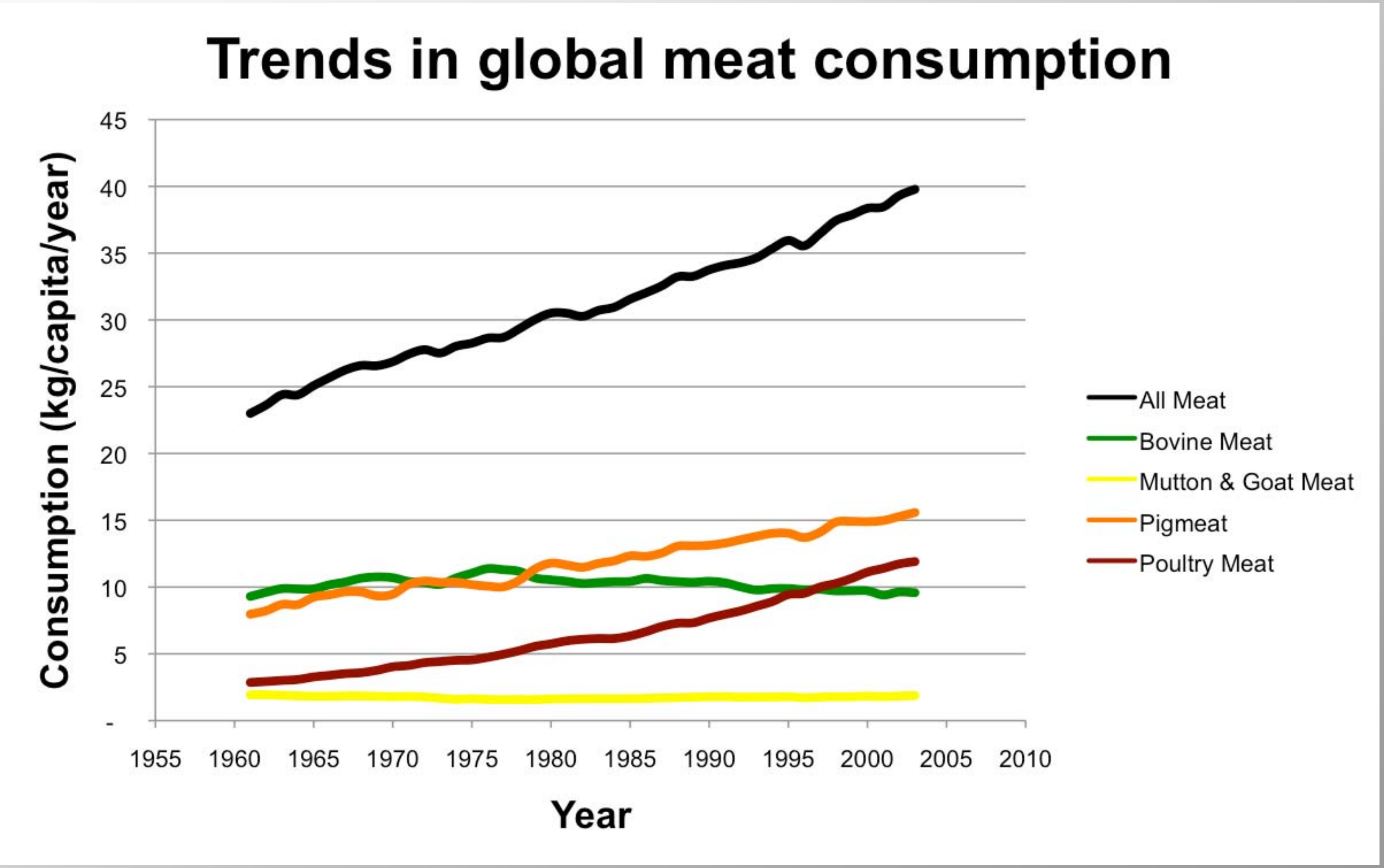
Source: FAO 2006

Global meat production, consumption and distribution

Global meat consumption is rising!

- At the turn of the century annual average global meat consumption was approx. 10 kg per capita, but increased to 23 kg per capita by 1961 and 40 kg per capita by 2005 (at which time total meat consumption was 284 million tonnes)
- World meat consumption is expected to double again by 2050

Trends in meat consumption globally



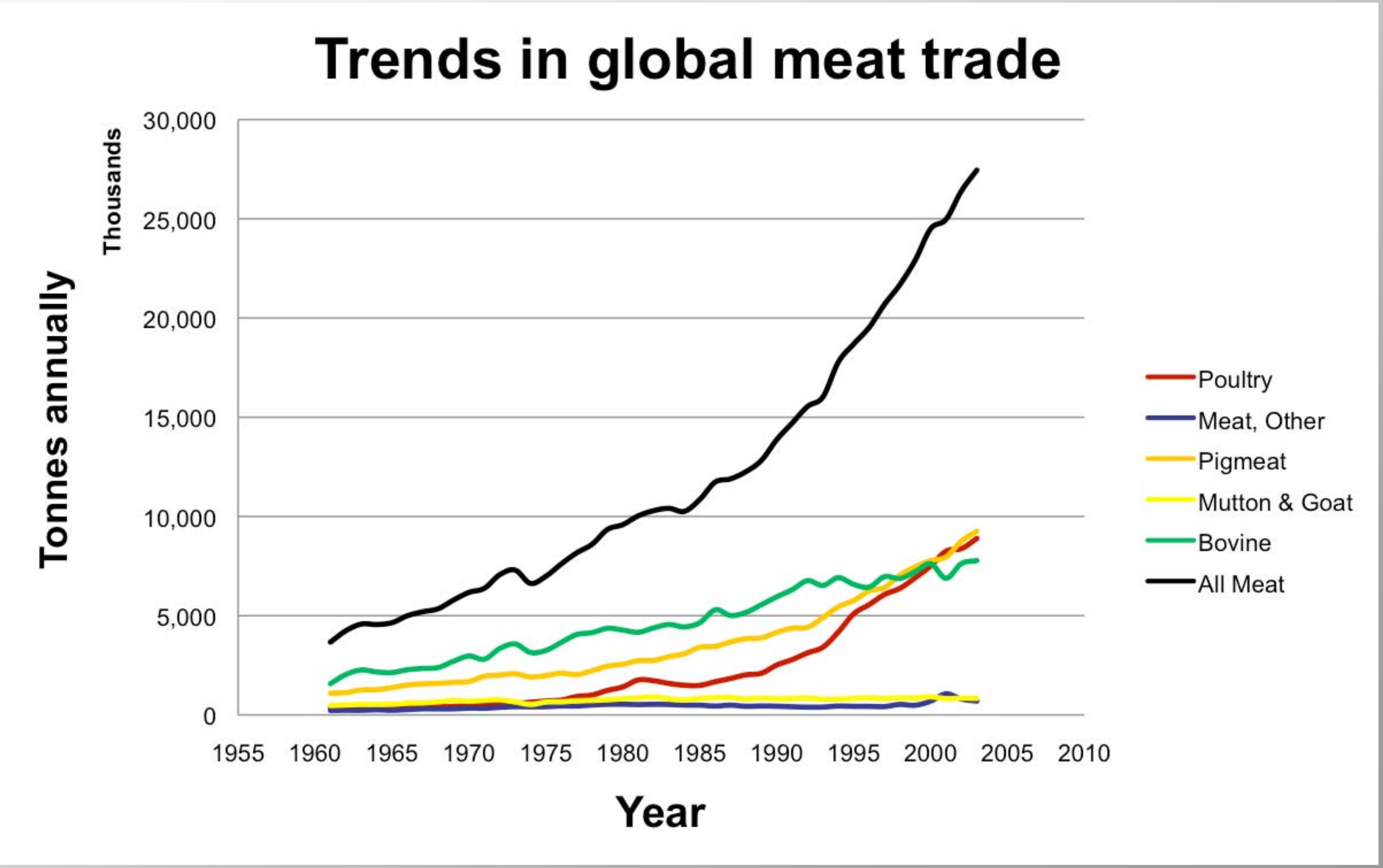
Source: FAO 2006

Meat production, consumption and distribution globally

Globalization is an important part of meat trade!

- Total traded meat increased from 3.7 million tonnes in 1961 to 27.5 million tonnes in 2003
- By 2001 traded meat accounted for approximate 12.8% of meat consumed
- The fastest growing traded meats are pig and chicken (5.6% and 6.8% annual growth, respectively)
- Meat trade expansion will likely continue until, at least, 2050

Trends in meat trade globally



Source: FAO 2006

Methods: Research questions, data and analyses

3 research questions

- What has been the impact of meat consumption on biogeochemical cycles in the Tokyo and NYC urban ecosystems?

- What have been the changes in the livestock production and pasture land use within the region where the NYC and Tokyo urban ecosystems are located (the peri-urban areas)?

- What have been the GHG emissions related to the consumption of meat in the NYC and Tokyo urban ecosystems?

Data: New York and Tokyo

- New York has no estimates for food consumption. We use national average American consumption following (Ngo and Pataki, 2008), provided by the USDA
- For New York, land use change data came from the USDA, US Census and State governments for the New York, New Jersey and Connecticut. We examined county level data only for New York

Data: New York and Tokyo

- Tokyo has estimates for meat consumption within the city, although to get accurate numbers requires estimating wholesale and retail source amounts
- Japanese land use data also include amounts of animals appropriated by Tokyo for consumption along with total amounts of land use for livestock. From these numbers we estimated the amount of land per Prefecture that is used by Tokyo residents for their animal protein consumption

Data: New York and Tokyo

- We decomposed types of meat into components: proteins, lipids, carbohydrates and further analyzed the amounts of N, C and P contained in each using atomic weights given the proportion of each in the different AAs and Fatty acids;

Analysis: New York and Tokyo

Table 2

Elemental composition of Meat
(grams per 100g meat)

	Nitrogen	Phosphorus	Carbon
Beef 95% Lean	2.93	0.20	13.13
Beef 85% Lean	2.58	0.17	18.62
Beef 75% Lean	2.23	0.15	24.22
Beef (average)	**2.58**	**0.17**	**18.66**
Chcken (raw)	2.32	0.18	13.24
Chicken (roasting only)	2.70	0.20	10.49
Chicken (average)	**2.51**	**0.19**	**11.87**
Pork - fresh leg 1	2.83	0.23	12.84
Pork - fresh leg 2	2.43	0.20	20.54
Pork - ground		0.18	11.63
Pork - sausage	1.84	0.14	25.82
Pork (average)	**2.37**	**0.19**	**17.71**
Lamb - lean and fat	2.37	0.17	19.57
Lamb - lean only	2.69	0.19	12.78
Lamb (average)	**2.53**	**0.18**	**16.18**
Turkey - products	2.45	0.16	13.77
Turkey - breast only	2.43	0.16	10.41
Turkey - sausage raw	1.82	0.18	12.96
Turkey (average)	**2.23**	**0.17**	**12.38**

Source: Stigletz, 2008

Analysis: New York and Tokyo

- Given the consumption of different types of meats (beef, chicken and pork) we estimated GHG emissions (in CO_2 equivalents) over time for each urban ecosystem

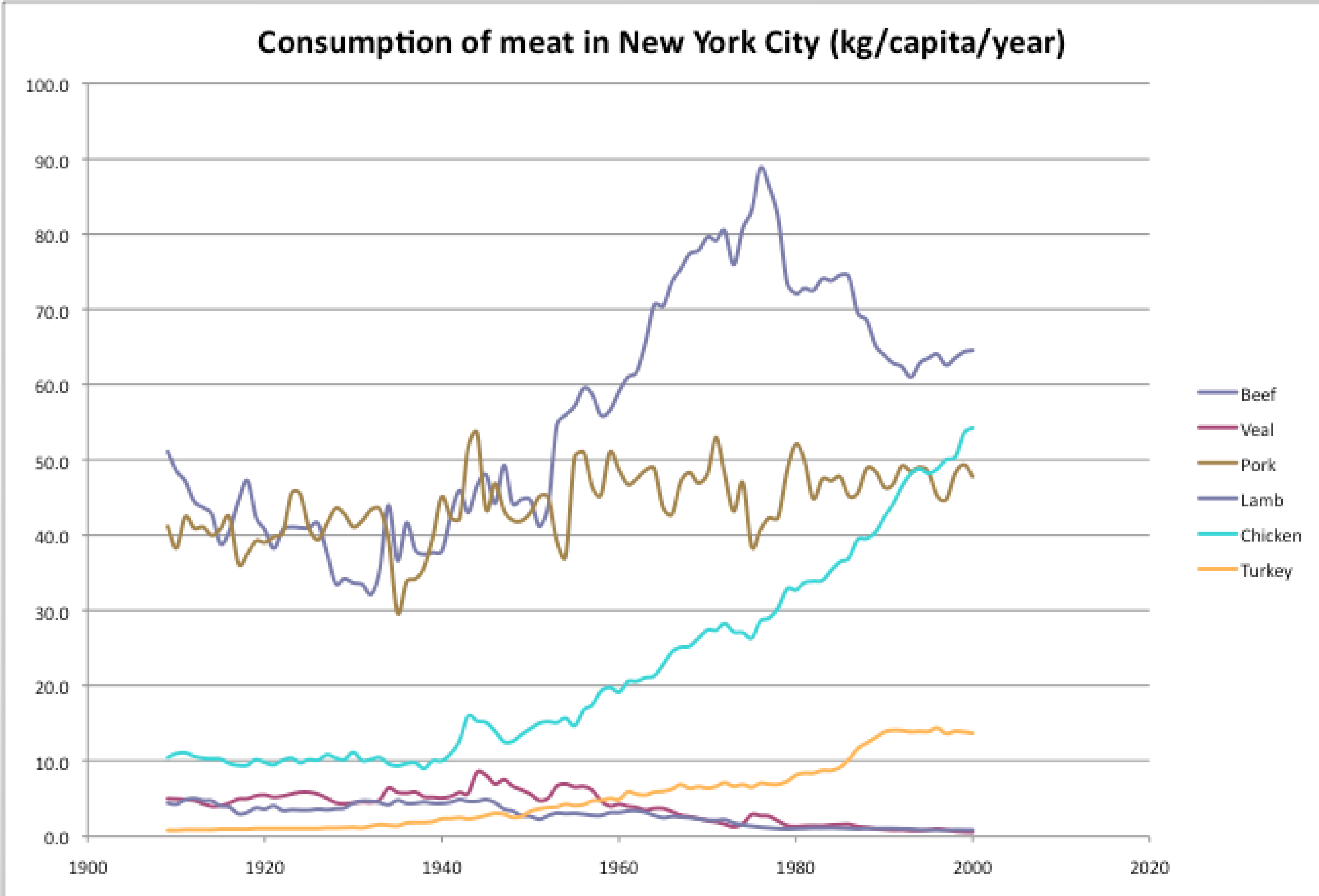
Table 1

Greenhouse gas impact of 1 kg of a given meat commodity

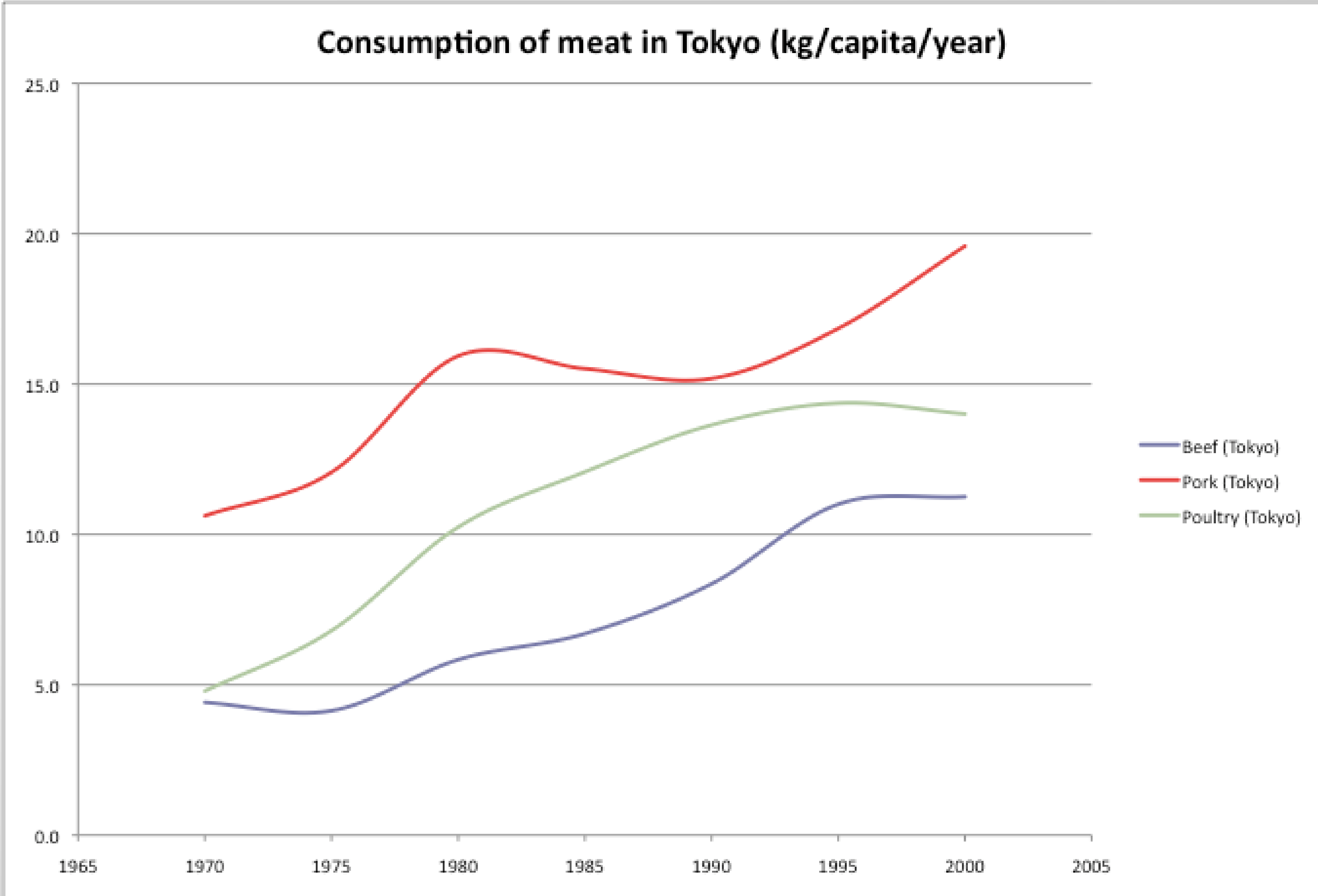
	Beef	Chicken	Pork
CO2 equivalent (kg)	14.8	1.1	3.8

Source: Faila 2008 using Subak (1999), Eshel and Martin (2006) and Pimentel (1997)

Findings: The impact of meat consumption in the NYC and Tokyo urban ecosystem



Source: USDA 2006


Consumption of meat in Tokyo (kg/capita/year)
25.0
20.0
15.0
10.0
5.0
0.0
1965
1970
1975
1980
1985
1990
1995
2000
2005
Beef (Tokyo)
Pork (Tokyo)
Poultry (Tokyo)

Findings: Consumption of meat in NYC and Tokyo

New York meat consumption

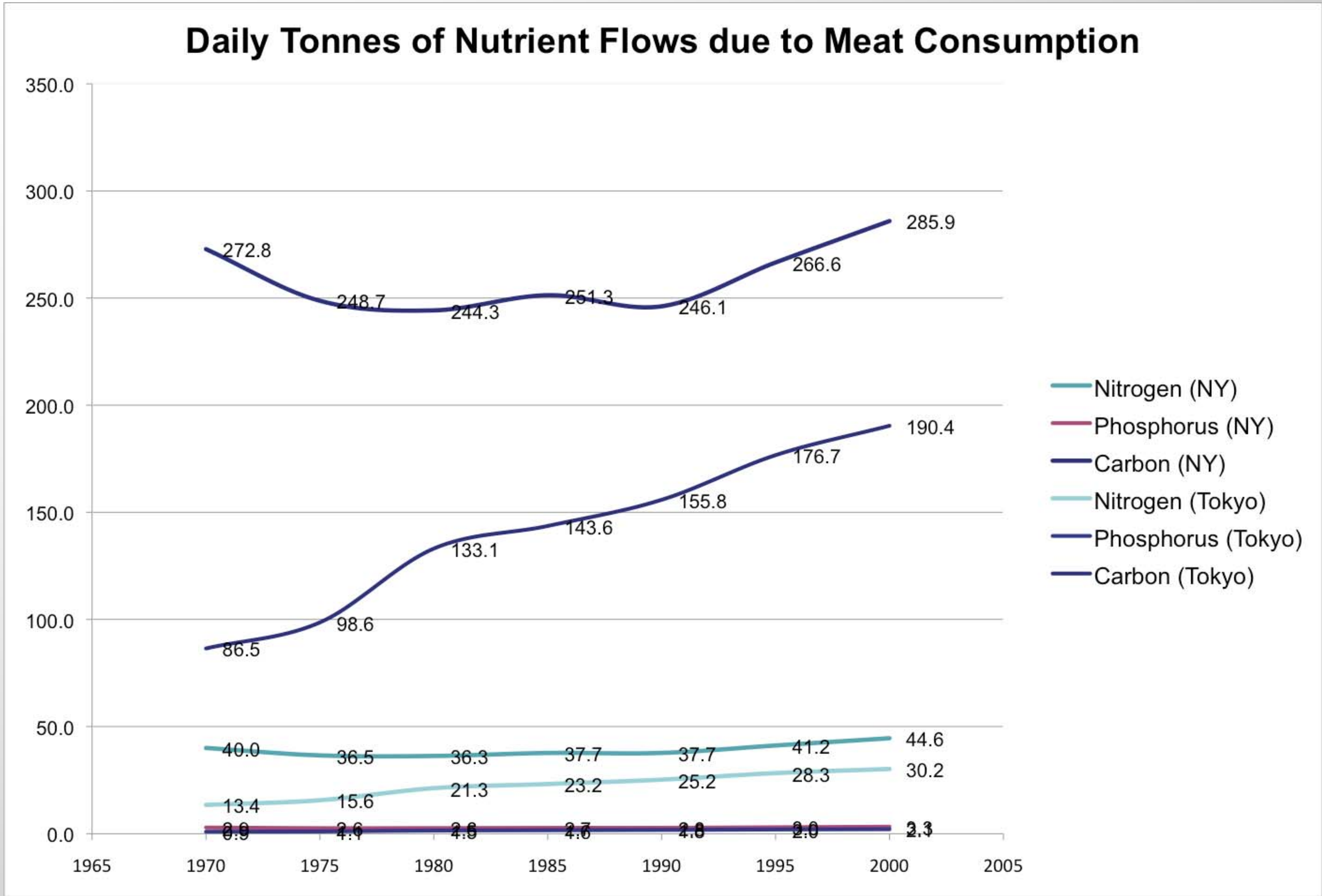
	Consumption (kg/capita)			
Year	Beef (NY)	Pork (NY)	Poultry (NY)	Total
1970	37.04	21.84	15.33	74.21
1975	39.01	17.44	14.89	71.34
1980	33.26	23.63	18.51	75.40
1985	34.51	21.64	20.68	76.83
1990	29.39	21.04	25.51	75.94
1995	29.19	21.94	28.17	79.29
2000	29.52	21.67	30.79	81.98

Tokyo meat consumption

	Consumption (kg/capita)			
	Beef (Tokyo)	Pork (Tokyo)	Poultry (Tokyo)	Total
1970	4.4	10.6	4.8	19.82
1975	4.1	12.1	6.8	23.00
1980	5.8	15.9	10.2	32.01
1985	6.7	15.5	12.1	34.29
1990	8.4	15.2	13.6	37.18
1995	11.0	16.8	14.4	42.22
2000	11.3	19.6	14.0	44.85

Findings: Impact on nutrient cycles

- From these numbers, using the data for average consumption levels, we can then calculate the inflows of each of these elements in to the New York City and Tokyo ecosystems via meat consumption
- We did this over time from 1910-2000 for NYC and from 1970-2005 for Tokyo and compared flows from 1970-2000


Daily Tonnes of Nutrient Flows due to Meat Consumption
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1965
1970
1975
1980
1985
1990
1995
2000
2005
272.8
248.7
244.3
251.3
246.1
266.6
285.9
86.5
98.6
133.1
143.6
155.8
176.7
190.4
40.0
36.5
36.3
37.7
37.7
41.2
44.6
13.4
15.6
21.3
23.2
25.2
28.3
30.2
Nitrogen (NY)
Phosphorus (NY)
Carbon (NY)
Nitrogen (Tokyo)
Phosphorus (Tokyo)
Carbon (Tokyo)

Findings: Changes in C, N and P flows into NYC and Tokyo (tonnes/day), 1970-2000

	NYC Total load (tonnes/day)			Tokyo Total load (tonnes/day)		
	Nitrogen (NY)	Phosphorus (NY)	Carbon (NY)	Nitrogen (Tokyo)	Phosphorus (Tokyo)	Carbon (Tokyo)
1970	40.0	2.9	272.8	13.4	0.9	86.5
1975	36.5	2.6	248.7	15.6	1.1	98.6
1980	36.3	2.6	244.3	21.3	1.5	133.1
1985	37.7	2.7	251.3	23.2	1.6	143.6
1990	37.7	2.8	246.1	25.2	1.8	155.8
1995	41.2	3.0	266.6	28.3	2.0	176.7
2000	44.6	3.3	285.9	30.2	2.1	190.4

Findings: Relationship of flows to stocks (NYC)

Table 11

Estimated total pounds of C, N and P in human stock of NYC, 2000
and ratio of inflows via meat consumption to stocks

Population type	Carbon	Nitrogen	Phosphorous
Female (young)	21,615,201	2,425,811	1,047,724
Male (young)	18,550,797	2,081,902	899,187
Female (adult)	93,495,741	10,492,753	4,531,890
Male (adult)	101,684,433	11,411,746	4,928,809
Total	235,346,172	26,412,212	11,407,609
Percent as daily inflows	0.27	0.37	0.06
Percent as annual inflows	98.22	136.38	23.11

Findings: Livestock production and pasture land change in the peri-urban area of NYC

- Livestock production in the NYC wider ecosystem is considered within the tri-state area (NYC's peri-urban area),

- We understand, however, the meat is increasingly traded, both within the USA (10 states account for over 90% of beef slaughtering and over 80% of hog slaughtering) and trans-nationally

Findings: Livestock production and pasture land change in the peri-urban area of NYC

- In 10 counties of NJ close to NYC, total pastureland acreage of all types dropped by approx. 70% from 261,519 in 1945 to 80,281 in 2002. During the same period, total farm acreage dropped by 56%
- In all of NY State, total farm acreage dropped by 56% from 17,568,471 acres in 1945 to 7,660,969 acres in 2002
- From 1974 to 2002, total farm acreage in Connecticut dropped by 18%

Findings: Livestock production and pasture land change in the peri-urban area of NYC

Farm land use change in the Tri-State region

(acres)

State	1974	1978	1982	1987	1992	1997	2002	Percent Change 1974-2002
New York	9,410,706	9,461,060	9,189,559	8,416,228	7,458,015	7,788,241	7,660,969	-18.6
New Jersey	961,395	987,309	916,331	894,426	847,595	856,909	805,682	-16.2
Connecticut	440,056	455,731	444,242	398,440	358,743	406,222	357,154	-18.8
Tri-State total	10,812,157	10,904,100	10,550,132	9,709,094	8,664,353	9,051,372	8,823,805	-18.4
USA (1000s)	1,017,030	1,014,777,	986,797	964,4701	945,532	954,753	938,279	-7.7

Source: USDA 2002 Census of Ag

Findings: Livestock production and pasture land change in the peri-urban area of NYC

		1962	1968	1974	1978	1982	1987	1992	1997	2002	% change 62-02
Tri-State Total	Cattle inventory	2,515	2,161	1,962	1,815	1,987	1,770	1,618	1,606	1,549	-38.4
	Hog inventory	280	214	163	208	179	137	126	112	99	-64.5
	Lamb and sheep inventory	180	122	101	80	84	87	94	79	NA	-56.1
	Broilers sold	NA	NA	3,034	1,635	1,125	3,018	2,081	1,843	3,161	4.2
USA	Cattle inventory	100,002	109,152	113,175	103,865	104,476	95,847	96,136	99,907	95,498	-4.5
	Hog inventory	57,000	55,265	45,504	57,697	55,366	52,271	57,563	61,206	60,405	6.0
	Lamb and sheep inventory	31,320	22,140	16,394	12,348	13,166	10,774	10,750	8,024	6,685	-78.7
	Broilers sold (1000s)	NA	NA	2,518	3,062	3,517	4,362	5,429	7,367	8,500	237.5

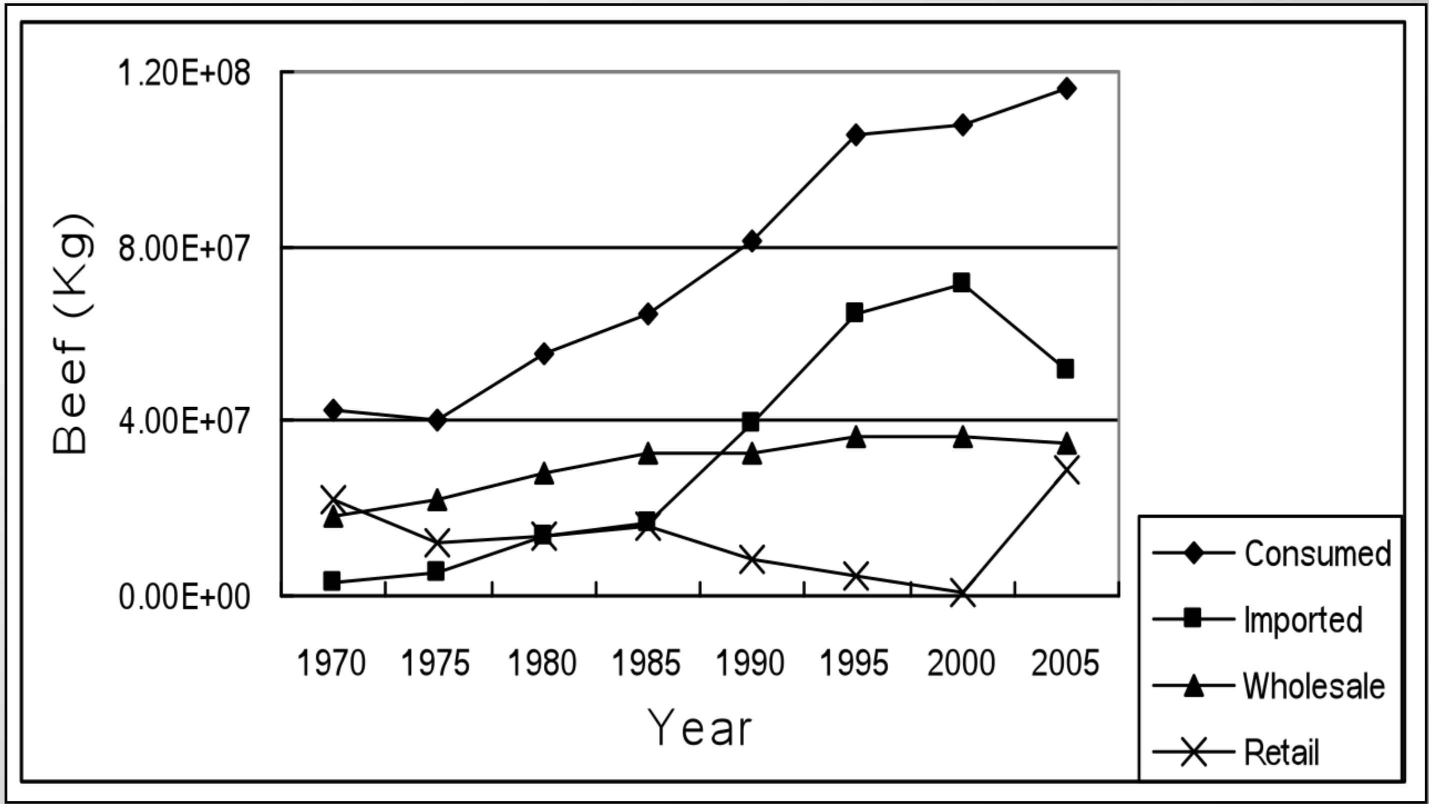
Findings: Livestock production and pasture land change in the peri-urban area of Tokyo

Table 8

Percentage of domestic farm land by region appropriated for raising beef consumed in Tokyo

	1970	1975	1980	1985	1990	1995	2000	2005
Hokkaido	24	8.2	2.8	2.4	1.3	1.4	1.4	6.4
Tohoku	13	10.7	9.7	8.3	6.5	7.2	7.9	12
Hokuriku	13.7	11.1	7.7	6.8	5.9	6	5.8	9.5
Other Kanto	25	21	19.2	18.5	13.4	13.5	13.5	18.7
Higashiyama	9.1	6.2	7	4.4	4.6	4	2.9	5.5
South Kanto	38.2	34.3	32.5	39.1	38.4	42.4	50.5	54.2
Tokai	6.5	5.9	6.7	6	3.4	2.6	2.7	6.4
Kinki	5.5	3.1	2.7	4.2	4.2	3.2	4.5	4.3
Chugoku	4.8	2.5	2.2	2.1	1.6	1.8	2.2	6.2
Shikoku	5	2.6	2.2	2.1	1.5	0.9	0.5	3.4
North Kyushu	4.8	2.4	2.3	2	1.1	0.6	0.2	3.9
South Kyushu	4.8	2.4	2.1	2	1.3	0.5	0.1	4
Okinawa	5.3	2.4	2.1	2	1	0.6	0.1	3.4
Japan	9.8	7.3	6.1	5.5	4	3.8	3.7	7.8

Findings: Livestock production and pasture land change in the peri-urban area of Tokyo



Amount of beef consumed in Tokyo and avenues of supply

Findings: GHG emissions from meat consumption in NYC and Tokyo

Table 13

New York City GHG emissions due to meat consumption

	CO2 equivalents (tonnes)				Per capita
Year	Beef	Pork	Poultry	Total	(kg)
1970	4,327,837	655,175	133,130	5,116,143	648.0
1975	4,314,091	495,109	122,384	4,931,585	660.0
1980	3,481,299	634,946	143,977	4,260,222	602.4
1985	3,675,775	591,671	163,682	4,431,127	615.8
1990	3,184,793	585,345	205,494	3,975,633	542.9
1995	3,308,362	638,331	237,252	4,183,946	546.4
2000	3,499,246	659,320	271,249	4,429,814	553.2

Tokyo GHG emissions due to meat consumption

	CO2 equivalents (tonnes)				Per capita
	Beef	Pork	Poultry	Total	(kg)
1970	629,768	389,067	50,815	1,069,650	110.9
1975	592,835	444,173	72,451	1,109,459	114.5
1980	818,012	573,824	106,725	1,498,561	158.2
1985	956,997	569,025	128,262	1,654,284	171.4
1990	1,198,856	559,429	145,442	1,903,727	196.4
1995	1,557,383	612,321	151,167	2,320,871	242.7
2000	1,600,313	715,315	148,080	2,463,707	256.4

Findings: GHG emissions from meat consumption in NYC

- Recent estimates for NYC suggest that per capita emissions are 7.1 tonnes per year and the total emissions for the city are 58.5 million tonnes per year
- Our estimates therefore suggest that the additional emissions from meat are an additional 7.8 percent of these totals. This is almost equal to the entire industrial sector's emissions for the city (~10 percent of total emissions)

Conclusions and recommendations

Conclusions

- Increasing dependence on non-locally produced meat, the nutrient loading from meat consumption and the GHGs emission suggest that these relationships affect each cities' risks and vulnerability
- While we find significant impacts from these linkages, they are not included in planning strategies or estimates of environmental impact by either urban governments or rural townships

Conclusions

- It is increasingly important, in a globalized world, to work out these connections and plan at the appropriate levels. For food security, like water security, municipalities must start taking appropriate action at the regional level

Recommendations

- Recommendations include:
  - Municipalities should include food assessments in their planning strategies. In order to do we need to start data collection and baseline construction efforts must be mounted;
  - To secure enough protein for growing populations (NYC is predicted to grow by 900,000 by 2030), for example, urban centers may need to include protection of pastureland in areas around each city

Recommendations

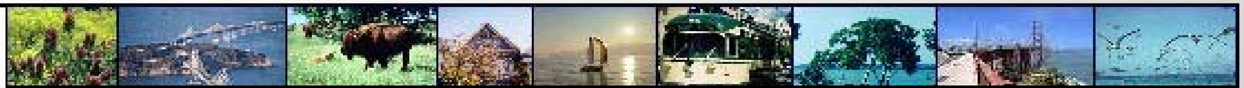
- Recommendations include:
  - To reduce nutrient burdens governments and civic organizations can encourage the consumption of alternative protein sources and place more emphasis on the re-use of sludge for (livestock) agricultural or municipal purposes
  - To reduce emissions, governments and civic organizations can encourage switching from beef to hog and poultry consumption. With this change we need to be careful to prevent the spread of emerging forms of infectious diseases

Recommendations

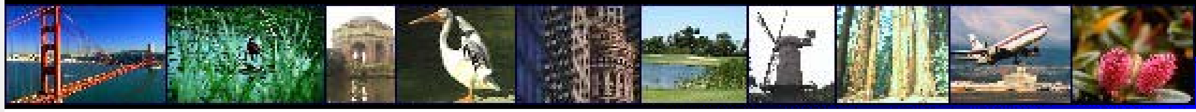
- Recommendations include:
  - Tokyo and New York may be conceived of as "*the canaries in the coalmine*" or the representatives of future trends for other cities suggesting the need for similar studies for other cities, particularly in the rapidly developing economies

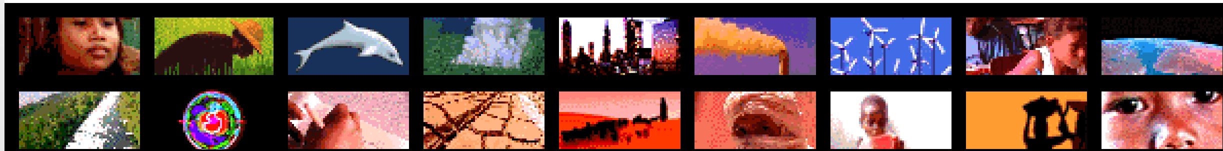
Acknowledgements

- The authors thank the organizers of the meeting and specifically Professor Shu-Li Huang for inviting us into this important project. The Cannon Foundation, Europe, supported part of our efforts through a generous Fellowship. Both Mr. Ryutaro Arai (TMG) and Mr. Kimihiro Eura (MAFF) gave freely of their time and expertise on datasets from TMG and MAFF. The JSPS and the UNU-IAS provided financial, research and administrative support for this work.



The environmental impact of meat consumption in NYC and Tokyo





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