

Lessons we can learn from our housing

Professor Brenda and Robert Vale
Victoria University of Wellington

brenda.vale@vuw.ac.nz

robert.vale@vuw.ac.nz

Why are we doing this?



Eco Design Advisor

Helping create **smarter** homes
...for you and the environment

What's the problem with the environment?





7,274,672,500 people

(at 12:15 on Thursday 24th September 2015)

= ?

One birth every 8 seconds

One death every 18 seconds

One person is added every 12 seconds

<http://www.census.gov/popclock/>

http://www.thelatestnews.com/wp-content/uploads/2015/04/Nasa_earth.jpg

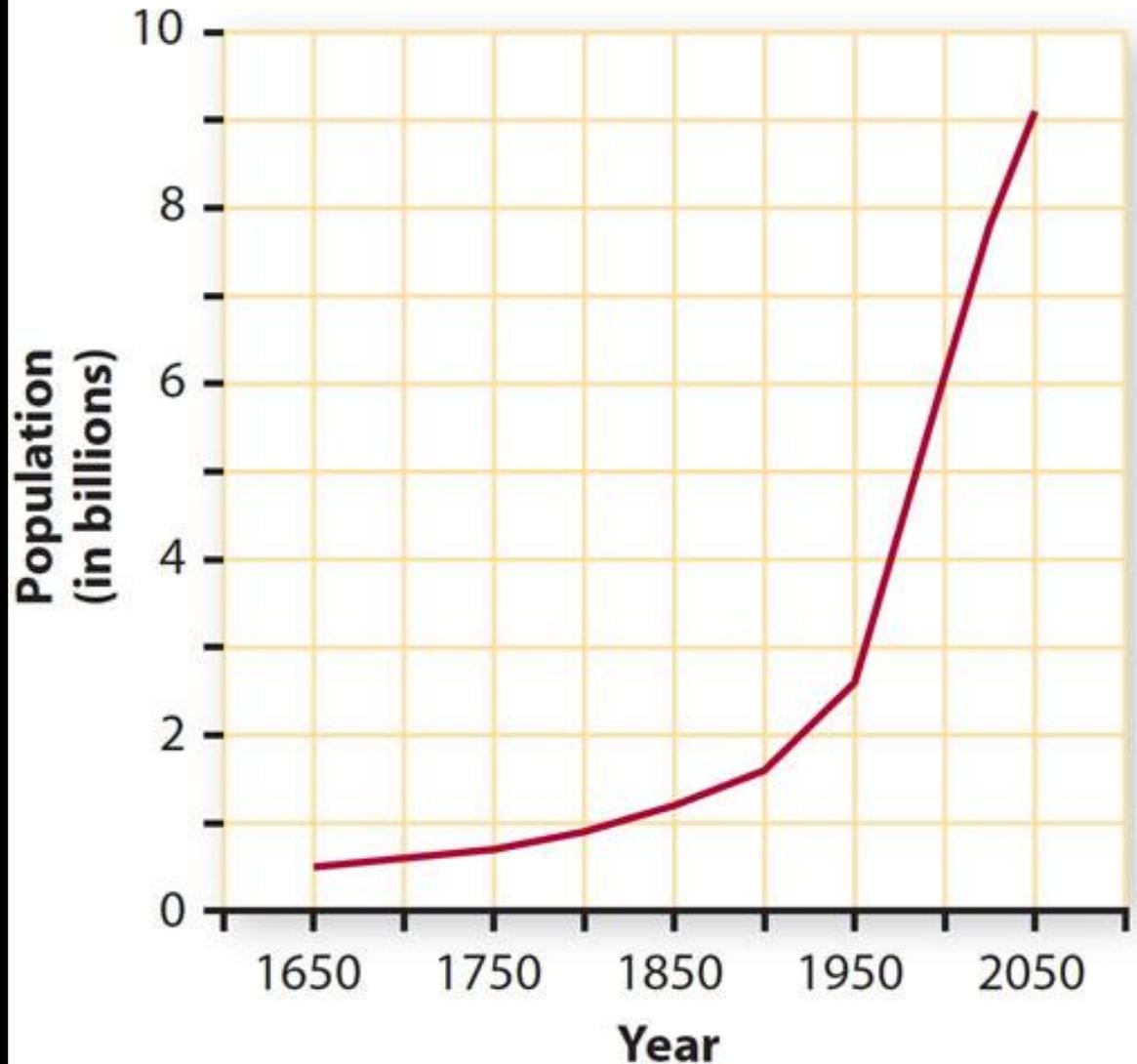
As recently as 1962 world population was less than half what it is now...

...and Wellington had zero-carbon public transport



There's no getting away from the problem that more people consume more resources...

World Population 1650–2050



Source: www.census.gov/ipc/www/world.html



...and it's not as though
we're meeting the
needs of the people
who are already here



In New Zealand houses have been getting bigger, from this in the 1940s –
2 bedrooms, 90 m²



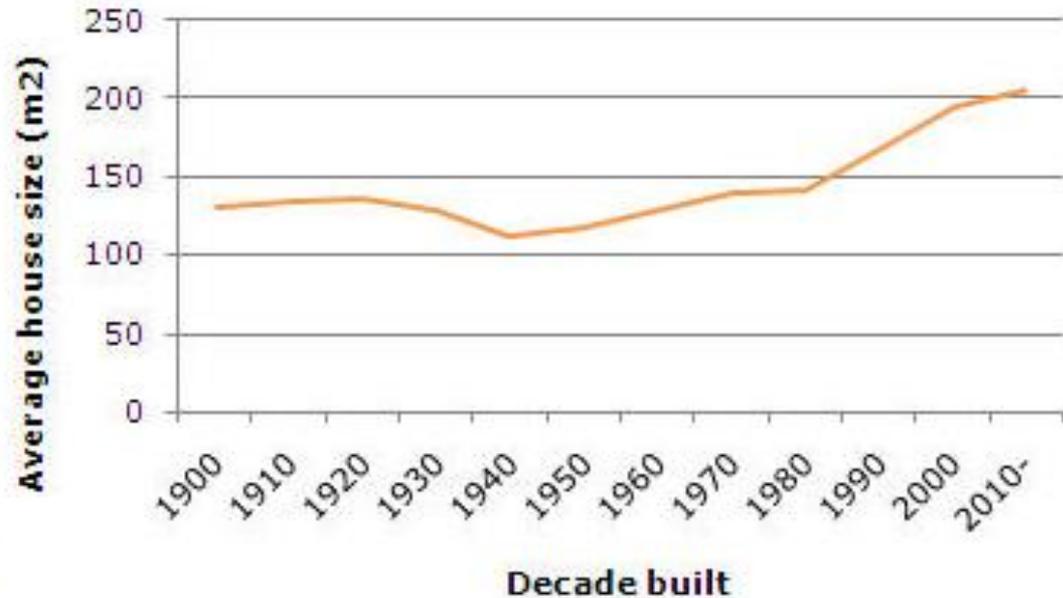
<http://www.realestate.co.nz/2568901>

Image 6 of 25

CLOSE X

...to this in 2015 – 2 bedrooms, 127 m²

Decade built	Average size (m ²)
1900	131.7
1910	135.3
1920	136.7
1930	129.8
1940	112.7
1950	117.5
1960	128.2
1970	140.2
1980	142.4
1990	166.4
2000	194.2
2010-	205.3



New Zealand houses now are roughly double the size they were in 1940

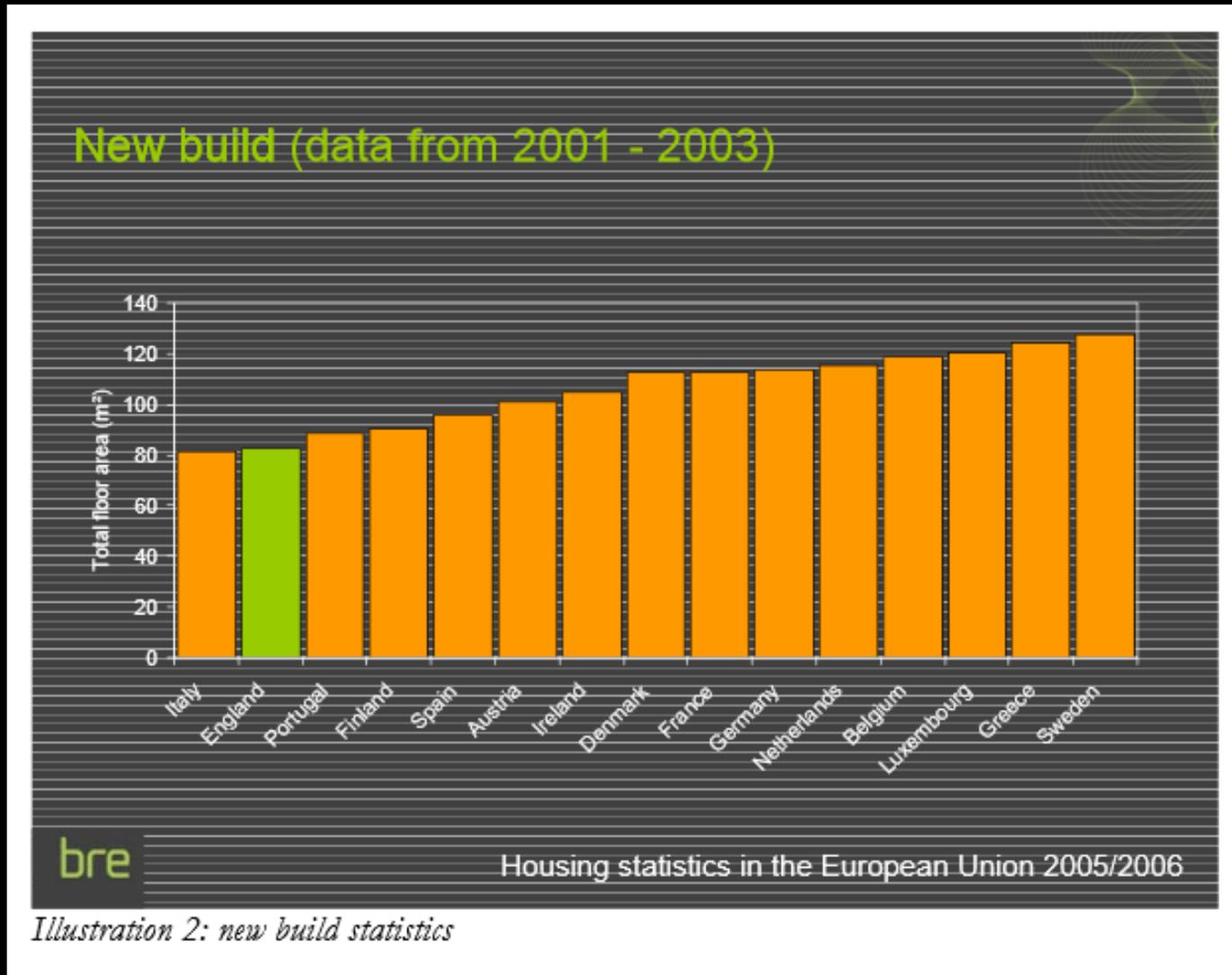
NZ population in 1940 was about 1.6 million

www.nzhistory.net.nz/war/new-zealand-and-the-second-world-war-overview

NZ population in 2015 is about 4.6 million

http://www.stats.govt.nz/tools_and_services/population_clock.aspx

The population has tripled
house size has doubled...



New houses in NZ are more than twice the size of new houses in the UK



This is in spite of England's notorious climate

“One of the most popular selling points of a kiwi home is the indoor outdoor flow”



<https://builderscrack.co.nz/blog/2015/05/13/successful-indoor-outdoor-flow/>

Why do we need so much indoor space in NZ when the outdoors is so pleasant?

A larger house uses more materials to build it and more energy to run it, it does not matter what materials you use



Designers spend a lot of time looking at alternative materials but seldom consider the size of the house



House type	Embodied energy GJ	Operating energy over 50 years GJ	Life-cycle energy over 50 years GJ
100m ² timber frame brick veneer	264	1,700	1,964
100m ² straw bale	185	1,650	1,635
100m ² straw stabilised adobe block	234	1,700	1,934
200m ² timber frame brick veneer	461	3,450	3,911
200m ² straw bale	349	3,300	3,749
200m ² straw stabilised adobe block	418	3,450	3,868

Double the size causes double the impact, the materials make very little difference

Embodied energy and large and small housing in New Zealand

A presentation for NZGBC event (August 2015-Wellington)

based on

a current PhD investigation at Victoria University of Wellington, School of Architecture

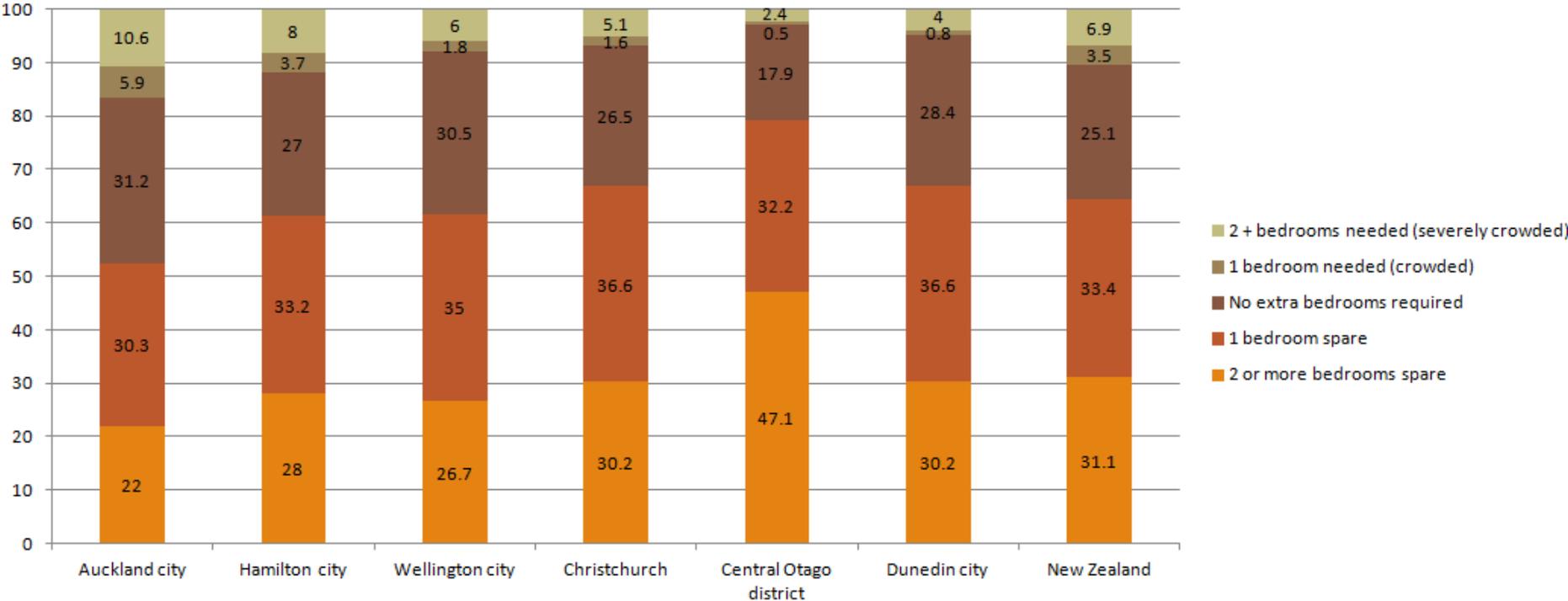
By:

Iman Khajehzadeh (PhD student)

Professor Brenda Vale (Professorial Research Fellow)

Some current research shows the situation in more detail

Crowding rates for major cities based on Territorial Authorities 2006 (Statistics NZ, 2014)



Features of large houses

- Extra bedrooms with no usual user(s)
- Double/triple living rooms
- Double or triple garaging
- Several bathrooms (including en-suites)
- Specialized rooms (i.e. play room, games room/rumpus room, study/office)

- For how long are these extra rooms really used?
- What is the effect of house size selection on embodied energy consumption?

Definition of number of rooms needed for each household type in this study

Household type	Rooms needed	Number of rooms needed
Single person	1 Kitchen + 1 living room + 1 Dining room + 1 Bedroom	4
Couple	1 Kitchen + 1 living room + 1 Dining room + 1 Bedroom	4
Couple with 1 child	1 Kitchen + 1 living room + 1 Dining room + 2 Bedrooms	5
Couple with 2 children	1 Kitchen + 1 living room + 1 Dining room + 3 Bedrooms	6

Number of couples in this study living in houses with extra rooms

	Number of extra rooms						
	0	1	2	3	4	5	6 and 6+
Number of couples	96	10	25	22	13	12	10

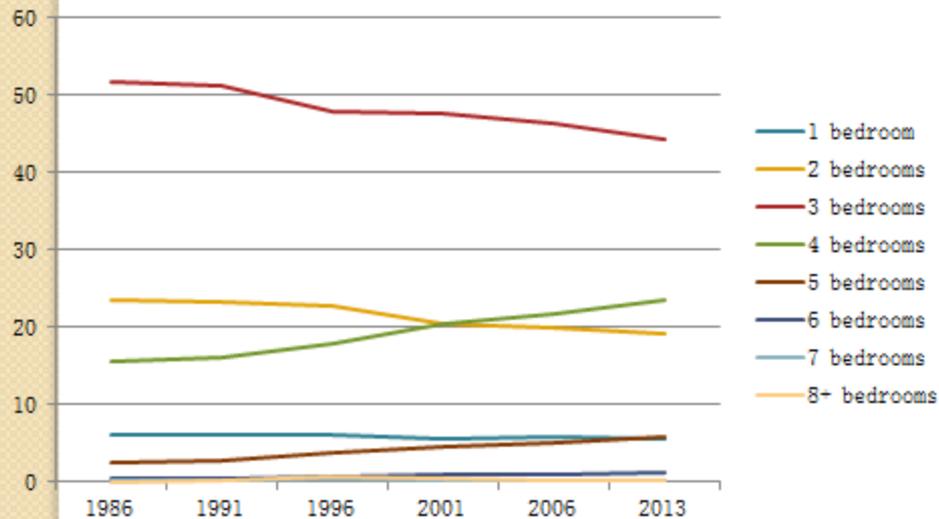
Discussion:

Based on the findings

- The initial embodied energy of a house with three extra rooms for a couple is almost double (86.6% more) that of a house with no extra rooms.
- Using the life-cycle energy equivalent of a house with 3 and 6 extra rooms over 75 years, it would be possible to make and operate 2.1 and 2.8 houses of the same materials and technology with no extra rooms for couples.

Changes in number of bedrooms over time in New Zealand houses:

	1 bedroom	2 bedrooms	3 bedrooms	4 bedrooms	5 bedrooms	6 bedrooms	7 bedrooms	8+ bedrooms	Average number of bedrooms
1986	6.1	23.6	51.6	15.5	2.6	0.4	0.1	0.0	2.86
1991	6.0	23.3	51.3	16.0	2.8	0.5	0.1	0.1	2.89
1996	6.1	22.7	47.9	17.9	3.7	0.7	0.4	0.6	2.97
2001	5.5	20.5	47.5	20.4	4.5	0.9	0.3	0.4	3.03
2006	5.8	19.8	46.3	21.6	5.0	1.0	0.2	0.3	3.05
2013	5.7	19.1	44.2	23.4	5.8	1.1	0.2	0.2	3.09



Other work by the same researchers shows that the problem of large houses is growing in NZ

Features of large houses

- Extra bedrooms with no usual user(s)
- Double/triple living rooms
- Double or triple garaging
- Several bathrooms (including en-suites)
- Specialized rooms (i.e. play room, games room/rumpus room, study/office)



One of the features of large houses is double or triple garaging. What does this mean in terms of environmental impact?

The average NZ house uses 10,695 kWh per year

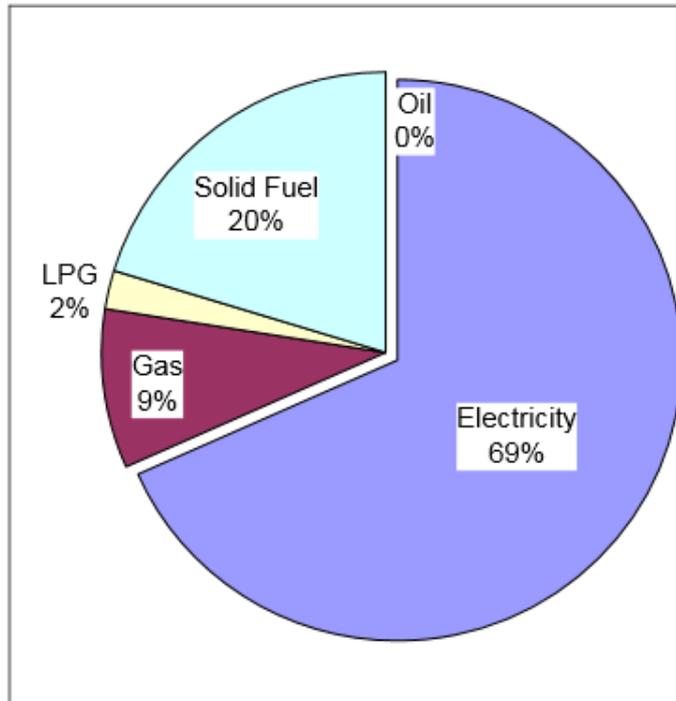


Figure i: Total energy use by fuel type

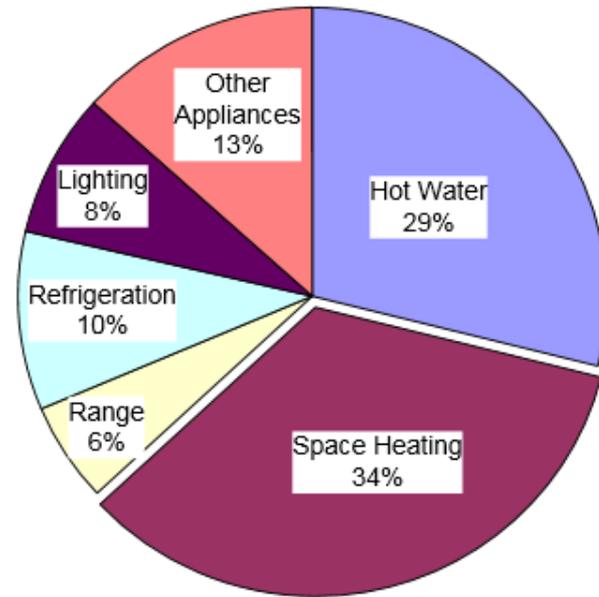
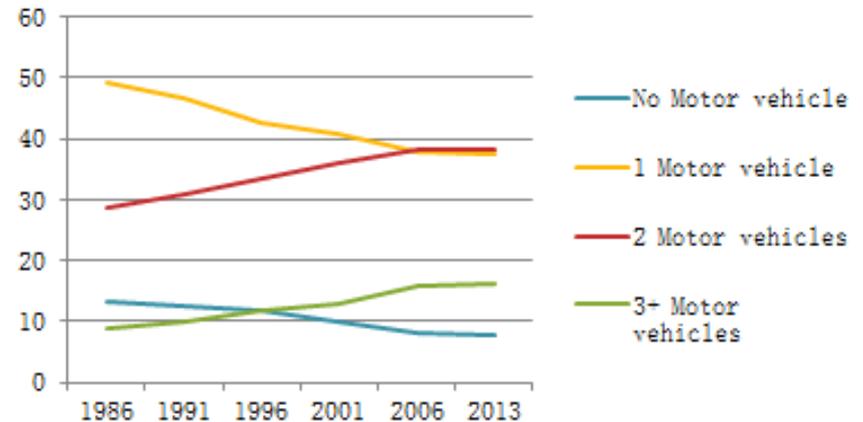


Figure ii: Total energy use by end-use

How does this compare with other energy uses?

Number of motor vehicles	No motor vehicle	1 motor vehicle	2 motor vehicles	3+ motor vehicles
1986	13.3%	49.3%	28.6%	8.8%
1991	12.4%	46.7%	31.0%	9.9%
1996	12.0%	42.8%	33.5%	11.8%
2001	10.1%	40.8%	35.9%	13.1%
2006	8.1%	37.9%	38.1%	15.9%
2013	7.9%	37.6%	38.4%	16.1%



New Zealand Census data show a significant increase over the last twenty years in households with two or more motor vehicles and a decrease in those without a car or with only one car

From research by Iman Khajehzadeh at Victoria University of Wellington

Average fuel consumption of the NZ car fleet in 2011 is just over 10 litres per 100 km (p9)

Average distance travelled per car is 12,200 km (p7)

so fuel used is 1,220 litres per car.

Ministry of Transport (2013) *The New Zealand Vehicle Fleet Annual Fleet Statistics 2012* February Wellington, Ministry of Transport

Energy content of 1 litre of petrol is 35.1 MJ/l (= 9.75 kWh)

Barber A. (2011) *NZ Fuel and Electricity – Total Primary Energy and GHG Emission Factors 2010* December Kumeu, AgriLINK NZ

This means an average car in NZ uses 11,895kWh per year
An average house uses 10,695 kWh per year



<http://www.enz.org/images/734-house-new-zealand.jpg>

<http://www.holden.co.nz/vehicle/calais/v-series/>

If the average fuel consumption of cars in 2011 is just over 10 litres per 100 km, what would be the effect of simply changing to smaller or more efficient cars?

Ford Fiesta Sport - 4.9 l/100km, 999cc, 5 seats,	\$27,340
Ford Falcon XR6 - 9.5 l/100km, 3,984cc, 5 seats,	\$54,340

Data from <http://www.ford.co.nz>

Initial cost saving \$27,000

Annual fuel saving with \$1,144

Based on 91 octane at \$2.039 per litre on 10 Sep 2015

<http://www.aa.co.nz/cars/motoring-blog/petrolwatch/september-2015-petrol-and-diesel-prices/>

Annual energy saving with Fiesta 5,470kWh

Toyota Prius - 3.9 l/100km, 1,800cc, 5 seats,	\$46,630
--	-----------------

Initial cost saving \$7,710

Annual fuel saving \$1,393

Annual energy saving with Prius 6,659kWh

EECA's "Right Car" website calls the Prius a "small hatchback" and the Falcon a "large saloon" but if it's so small, why are there so many Prius taxis?



<http://greencabs.co.nz/booking/wellington-taxi/>



The Pope caused a stir in Washington recently...

NEW YORKER
FREE TOTE
SUBSCRIBE
\$1 A WEEK
NEW YORKER

[Sign in](#) | [Link your subscription](#) | [TNY Store](#)



THE NEW YORKER

[NEWS](#) [CULTURE](#) [BOOKS & FICTION](#) [SCIENCE & TECH](#) [BUSINESS](#) [HUMOR](#) [CARTOONS](#) [MAGAZINE](#) [VIDEO](#) [ARCHIVE](#) [SUBSCRIBE](#)

SEPTEMBER 23, 2015

POPE FRANCIS AND HIS LITTLE FIAT

BY JOHN CASSIDY



JOHN CASSIDY

SHARE TWEET



...but you have to “do the numbers”

<http://www.stuff.co.nz/national/politics/69453073/Crown-looks-to-trade-in-its-luxury-limo-fleet>

NZ Government's BMW 730Ld - 5.6 litres/100km Diesel

<http://www.whatcar.com/car-reviews/bmw/7-series-saloon/730ld-se-4dr/summary/65943>

Pope Francis' Fiat 500L – 7.7 litres/100km Petrol

<http://www.newyorker.com/news/john-cassidy/pope-francis-and-his-little-fiat>

The Model Year 2013 adjusted fuel economy for light duty vehicles in the USA is 24.1 mpg, which is 9.8 l/100km, so the Pope is doing a bit better than average, but not as well as he could...

USEPA (2014) *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2014* October. Washington, United States Environmental Protection Agency



1958 Fiat 500 4.5 l/100km

Anon (1958) *International Automobile Parade Zurich*, Arthur Logoz, p103

<https://drive-my.com/images/01-Fiat-Nuova-500.jpg>

<http://www.classiccarcatalogue.com/F/fiat%201958%20500%20nuova.jpg>

In the early 1970s the ecologist Barry Commoner wrote a book called *The Closing Circle* in which he proposed his four laws of ecology:

1. Everything is Connected to Everything Else
2. Everything Must Go Somewhere
3. There Is No Such Thing as a Free Lunch
4. Nature Knows Best

So we should not consider the house in isolation

We could halve our energy consumption and our CO₂ emissions and save money simply by choosing to drive smaller cars

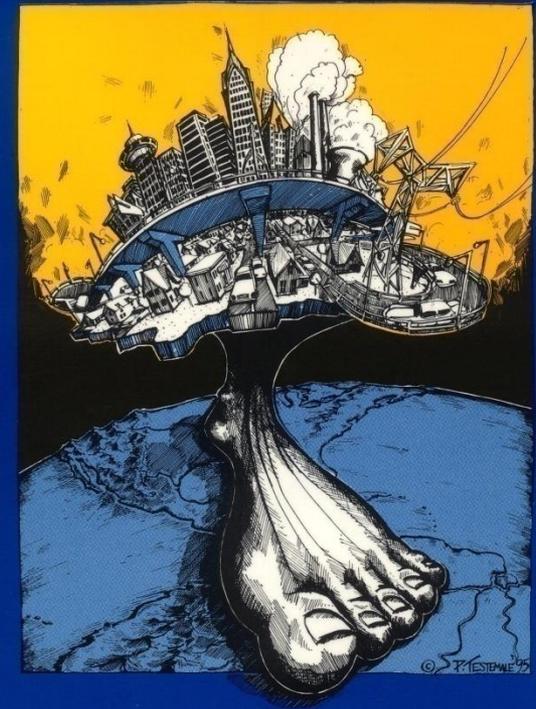
Why do we not choose to do this?

To measure environmental impact, our research makes use of Ecological Footprint, developed in Canada by Wackernagel and Rees (1996).



OUR ECOLOGICAL FOOTPRINT

*Reducing Human
Impact on the Earth*



C THE NEW
CATALYST
BIOREGIONAL SERIES

**MATHIS WACKERNAGEL
& WILLIAM REES**

Illustrated by Phil Testemale

The Ecological Footprint is the area of land that would be required to provide sustainably all of a society's goods and services. It can be measured from the scale of the individual to the scale of a whole country

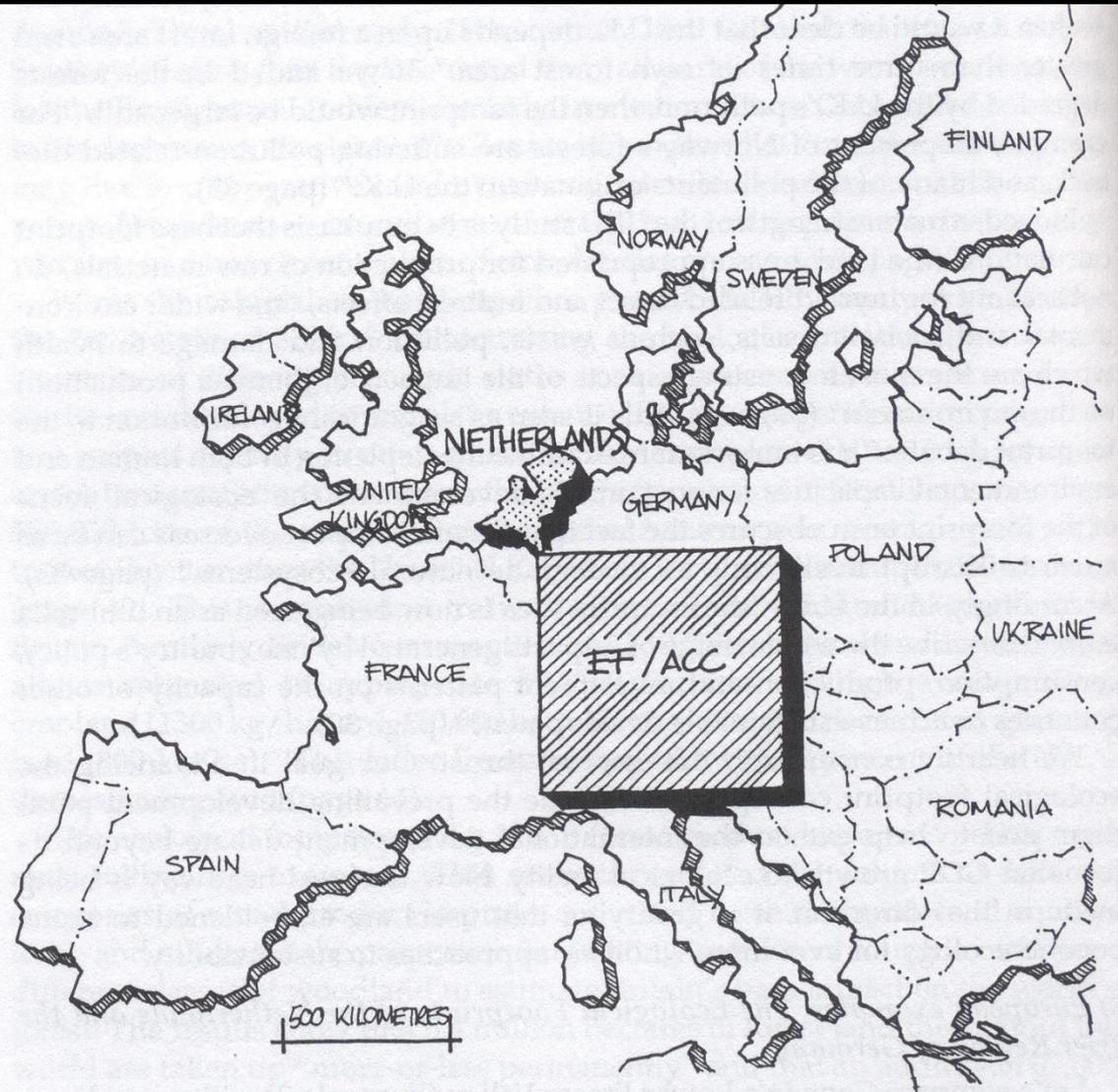


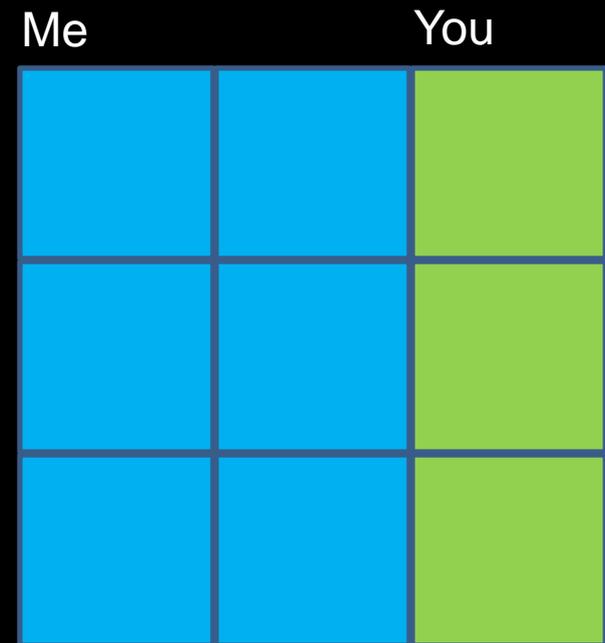
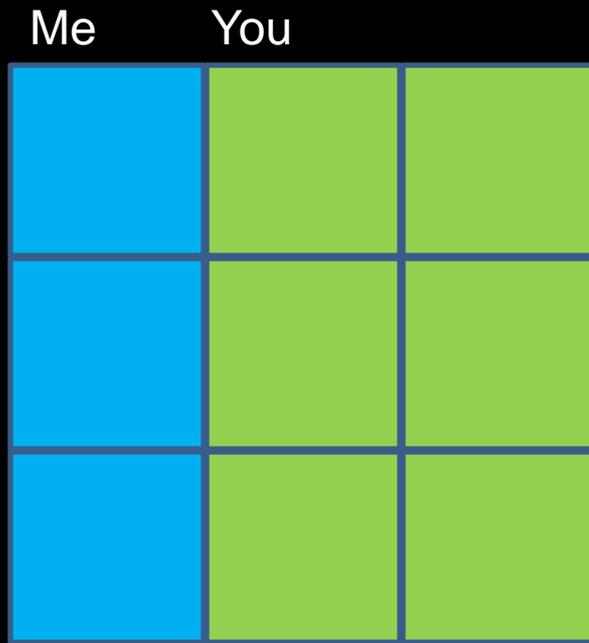
Figure 3.8: For urbanization, food, forest products and fossil fuel use, the Dutch use the ecological functions of a land area over 15 times larger than their country.

Ecological Footprint is measured in “global hectares” (gha).
A global hectare is a hectare of land of average productivity



A hectare of land can be used to produce energy or food or fibre or materials, but it cannot produce all simultaneously

Land is a finite resource, there is a fixed quantity



If land is the measure, rather than money,
it is clear that **if I want to have more...**
you will have to have less

The current “fair share” is around 1.8gha per person

USA - footprint 6.8gha



Indonesia - footprint 1.2gha

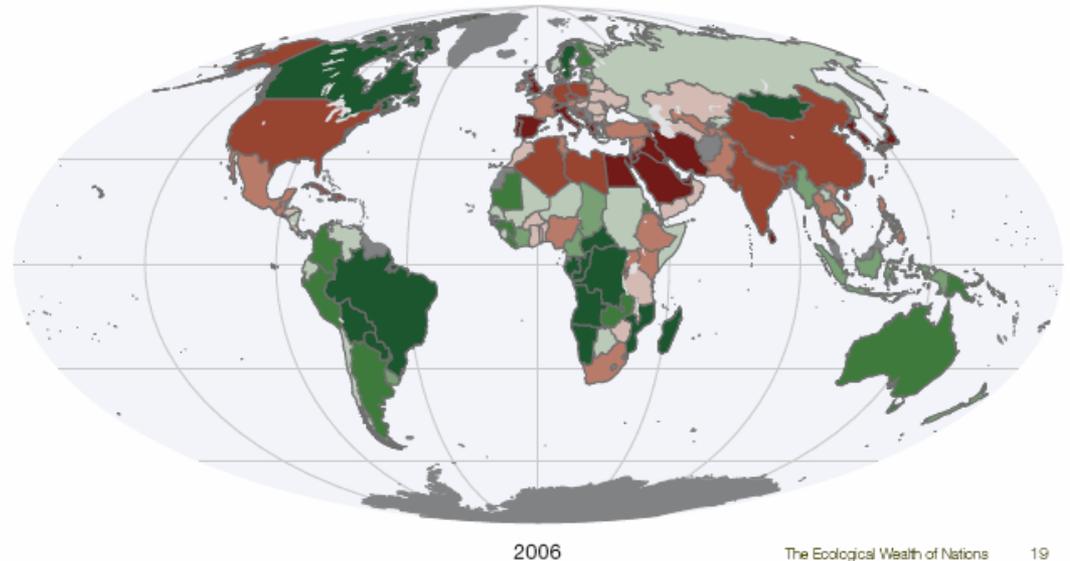
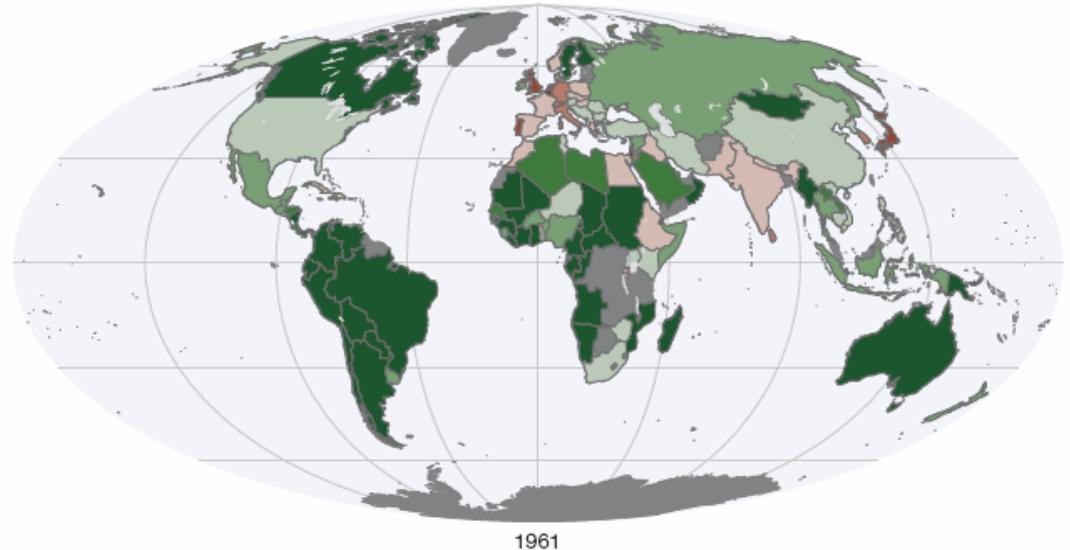


Nations which have footprints larger than a fair share are stealing from poorer nations the chance to improve their situation

The change in Ecological Footprint from 1961 to 2006

Countries in green were living within their biocapacity, the area of land they had available

- Footprint more than 150% larger than biocapacity
- Footprint 100-150% larger than biocapacity
- Footprint 50-100% larger than biocapacity
- Footprint 0-50% larger than biocapacity
- Biocapacity 0-50% larger than Footprint
- Biocapacity 50-100% larger than Footprint
- Biocapacity 100-150% larger than Footprint
- Biocapacity more than 150% larger than Footprint
- Insufficient data



Global Transport Scenarios 2050

World Energy Council

Project Partners
IBM Corporation
Paul Scherrer Institute

less than 40 years of oil...

In its 2010 survey of energy resources, WEC estimated global proven reserves of oil and natural gas liquids (NGLs) at the end of 2008 to be around 1,239 billion barrels (Table 4). These conventional reserves were expected to last for another 41 years at 2008's consumption rate.

We exceed our bio-capacity by using finite resources such as oil, gas and coal, but when they are gone all resources will have to come from the land

Why we use ecological footprint...

Bio-fuel vehicles	Land area for 10,000 km/year
Current diesel cars burning vegetable oil	10,000m ²
Horse eating grass and cereals	8,500m ²
Current petrol cars burning ethanol	3,500m ²
Efficient diesel cars burning veg. oil	3,700m ²
Efficient petrol cars burning ethanol	1,900m ²
Electric vehicles	
Hydrogen cars using solar power	75-90m ²
Hydrogen cars using wind power	18-22m ²
Electric cars using solar power	25m ²
Electric cars using wind power	6m ²

All options here are zero-carbon, but the land needed for the same amount of transport varies from 6m² to 10,000m².



We wrote this book to explore the impacts of how we behave in the west, using EF as the measure

This can offer a guide to ways that we could reduce EF by changing behaviour, without having to build new houses

Robert and Brenda Vale

TIME TO EAT THE DOG?

the real guide to

sustainable living



Thames & Hudson

During extreme situations scarce resources are rationed to ensure a fair share for all

German He 111 bomber over Surrey Docks, London, at 1700 hours on 7 Sep 1940



R.B.1
18

MINISTRY OF FOOD
1943-1944

MF

SERIAL NO. 1
BP 380280

RATION BOOK

Surname *Pharator* Initials *Gilman*
Address *East Walton* *H.R.*
Isings Lane

IF FOUND RETURN TO ANY FOOD OFFICE	F.O. CODE No. E - B 3
------------------------------------	---

The Ecological Footprint is divided into two parts –

PERSONAL – things over which we have some personal control

COLLECTIVE – things which we have as a result of being citizens of a nation

If we consider the categories in turn it is possible to see what needs to be done to achieve the necessary reduction of at least 70% for a typical western country

What would life be like if we reduced all categories by 70%?

FOOD - food choices make a difference

	kcal	Ecological footprint m ²
Bowl of rice and vegetables (100gm cooked rice and 100gm bean sprouts)	186	0.18
Cheeseburger	300	1.40





If you must
eat meat go
for a little of
the low
impact option
in terms of
greenhouse
gases



You could either have an efficient car or you could choose to fly, but not both





Second hand or antique furniture reduces the environmental impact of a house by making better use of resources.

Flea market in Tokyo



<https://ourtongnian.files.wordpress.com/2008/07/flea-market-023.jpg>

Consuming things that other people no longer want is one path to take to reduce impact. However, it is not just the obvious things like clothes, white goods and electronic goods that have an impact

Some paw prints are bigger than the impact of cars

Chihuahua	0.28 ha
Scottish terrier	0.42 ha
Border collie	0.84 ha
Alsatian	1.10 ha

Smart Fortwo Coupe	0.18 ha
Volkswagen Golf	0.29 ha
Holden Commodore	0.42 ha
Toyota Landcruiser	0.62 ha



=



<http://tarmacphilosopher.files.wordpress.com/2008/02/2008-08/02/2008-smart-fortwo-pure.jpg>



=

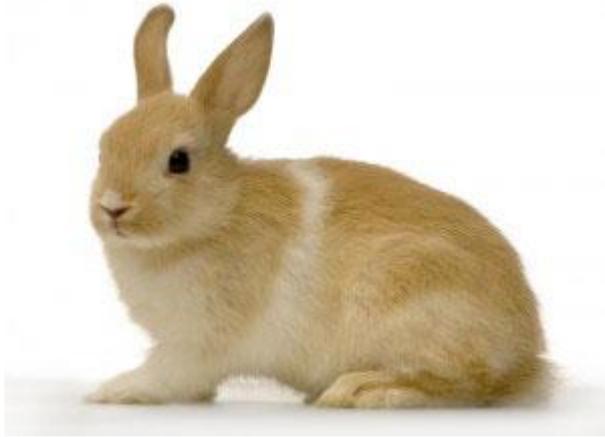




Which is worse for the planet?

(a clue, it's not the Humvee...)





<http://www.thehealthypetclub.co.uk/category/160> <http://blogs.kcrw.com/goodfood/2013/09/weekend-cooking-project-le-pigeons-smoked-rabbit-pie-with-cheddar-crust-and-mustard-ice-cream/>

The best pets are ones you can eat



**Were you living in Wellington in
the 1950s?**

Do you know someone who was?

I'm looking for people to be part of a survey and focus group (Ethics Approval no. 17719), to gather information on life in the 1950s, as part of a Masters degree entitled the 'Ecological Footprint of Wellingtonians in the 1950s'.

If you are interested or would like some more information please contact Carmeny Field (Victoria University of Wellington) via email fieldcarm@myvuw.ac.nz or phone (04) 463 6253.



**Carmeny Field
calculated the EF
of Wellington in
the 1950s and
also talked to
people to gain a
consensus of
what it was like
living here at that
time.**

In 50 years the Ecological Footprint of Wellington, the capital of New Zealand, has increased by 43% - each person in Wellington is using 43% more resources...

Category	EF 1956 ha	EF 2006 ha	% difference
Housing	0.07	0.12	+71
Transport	0.23	0.47	+104
Food	0.75	0.77	+3
Consumer goods	0.40	0.72	+80
Services	0.23	0.35	+52
Total ha	1.68	2.41	+43
<i>Total gha (allowing for land productivity)</i>	<i>4.19</i>	<i>6.03</i>	<i>+43</i>



1956
and
2006



Nearest year available to 2006	1956	2008	difference
Positive quality of life	86%	95%	+ 9%
Satisfaction with work/life balance	96%	73%	- 13%
Ecological Footprint	4.2gha	6.0gha	+ 43%

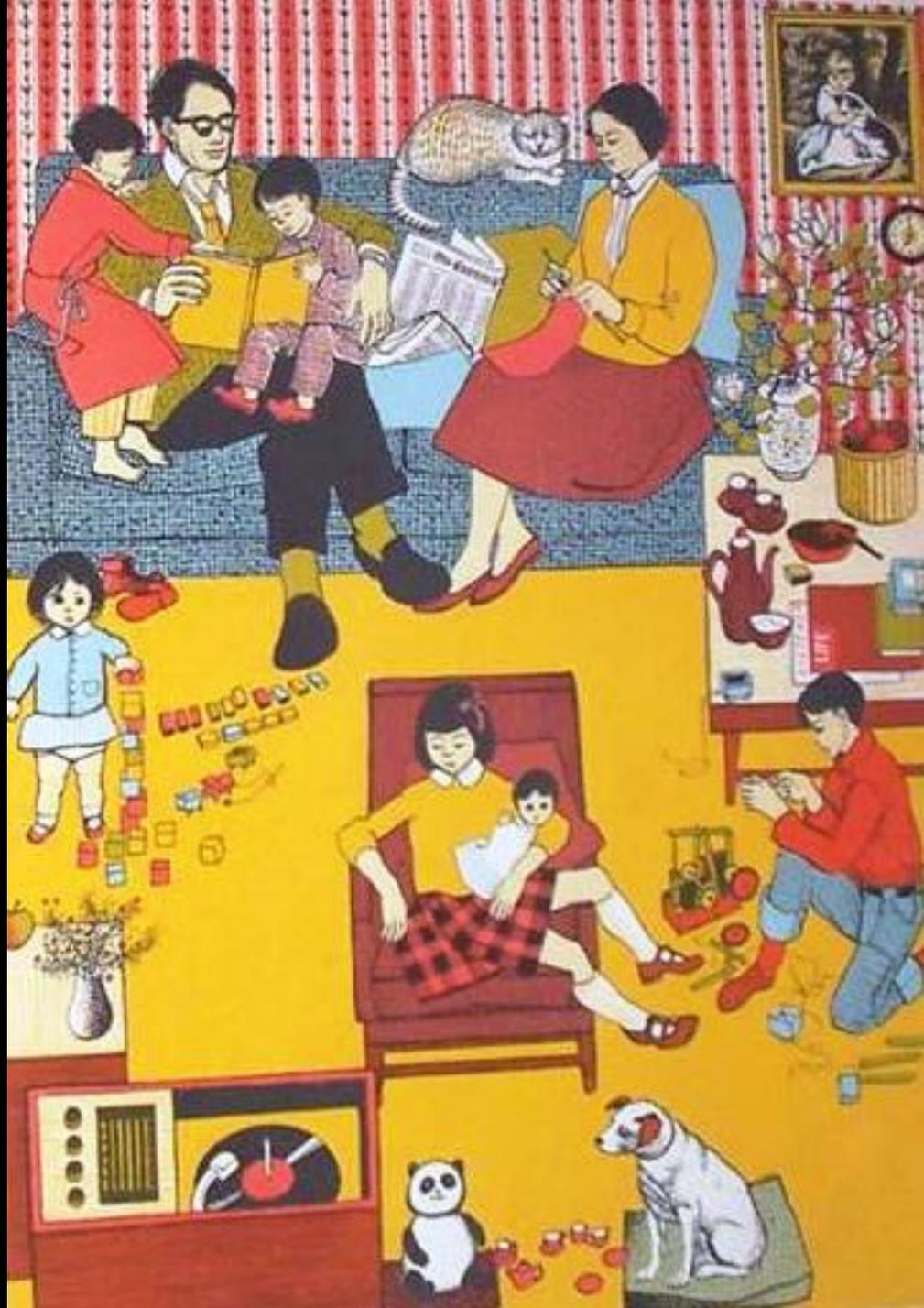
...but this wealth does not seem to be making us happier



<http://www.whangareiartmuseum.co.nz/sites/default/files/imagecache/collection-zoom/IM03.jpg>

http://blog.travelpod.com/travel-photo/em_n_abs/worldtrip2006/1171676400/abbie_040.jpg/tpod.html

In the research by Carmeny Field, 86% of the sample of 30 people (now aged 58-96) who lived in Wellington in the 1950s thought life then was good or better than good



Are we all suffering death from consumption?



Fading Away, Henry Peach Robinson, 1858

We can no longer afford to live the consumer dream



*270-h.p. V8 also available at extra cost. Also Ramjet fuel injection engines with up to 283 h.p.

That new V8 in the '57 Chevrolet is as quiet as a contented cat and as smooth as cream. And it's cat-quick in response when you ask for action!

No household tabby sitting in a sunny window ever purred more softly than Chevy's new V8 engine. It's so kitten-quiet and cream-smooth that you can scarcely even tell when it's idling.

But when you nudge the accelerator, you know it's there, all right! It pours out the kind of velvety action that helps you be a surer, safer driver. Its right-now response keeps you out of highway emergencies. It overpowers steep hills with such ease they seem like level laundrapes.

New Chevy V8 engine options put up to 245* high-compression horsepower under your command. With 283 cubic inches of displacement, this beautifully designed V8 is a new, bigger and better

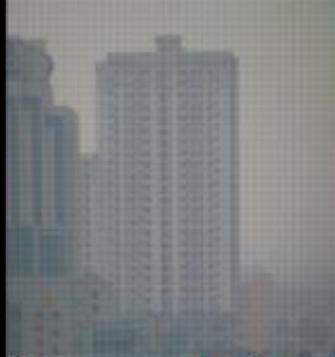
edition of the engines that have put Chevrolet at the top of the performance ladder. It's sure, sure—but as tame to your touch as a purring pussycat.

Try the smoothest V8 you ever put a toe to, and all the good things that go with it. Like new Turbofide—the first and only triple-turbine automatic drive (an extra-cost option). And Chevy's own special sweet and solid way of going. Stop by your Chevrolet dealer's. . . . Chevrolet Division of General Motors, Detroit 2, Michigan.

Chevy puts the purr in performance



We need to think
about taking no more
than our fair share



LIVING WITHIN A FAIR SHARE ECOLOGICAL FOOTPRINT

Edited by Robert Vale
and Brenda Vale



Society needs to encourage behaviour change towards low-footprint living.