

The Impact of Land Use on Lake Water Quality in Ireland 2004-2009

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Existing Research



- **Small catchment analysis**
 - e.g. Oona Catchment, Johnstown Castle. Kramers et al. (2009), Watson and Matthews (2008), Jordan et al. (2007), Kurz et al. (2006), Bourke et al. (2009)
- **Nutrient export modelling**
 - GLEAMS, DAYCENT, MACRO, AMINO, SWAT, NERM
- **Statistical analysis across catchments**
 - O'Donoghue et al. (2010) NUIG, "Spatial Relationship between Economic Activity and River Water Quality"
 - Donohue, McGarrigle & Mills (2006) "Linking catchment characteristics and water chemistry with the ecological status of Irish rivers"
 - Neil (1989) "Nitrate Concentrations in River Waters in South-East of Ireland and their Relationship with Agricultural Practice"

Lake Water Quality



- Polluted via nutrient enrichment
 - Leading to plant growth >
 - > phytoplankton growth(indicated by chlorophyll levels)
 - > algal blooms >reduced water clarity & light exclusion & reduced oxygen levels
- lake water quality measured by
maximum *chlorophyll a* concentration

Lake Water Quality 2004-09

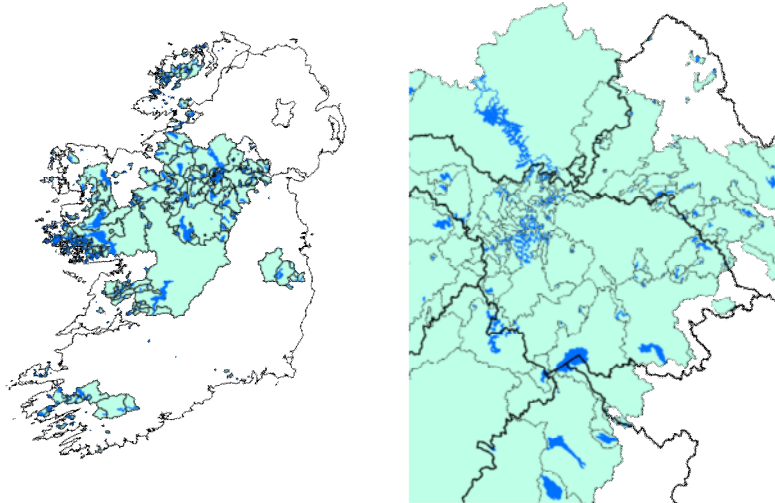


- 216 lakes, min 2 yrs, max 6 yrs data

Lake Trophic Category	Annual Max. Chlorophyll mg/m^3	Level of Pollution	Max. Chlorophyll readings	%
Oligotrophic	<8	Very low	511	50
Mesotrophic	8<25	Low	339	33
Moderately eutrophic	25<35	Significant	60	6
Strongly eutrophic	35<55	Strong	56	5
Highly eutrophic	55<75	High	32	3
Hypertrophic	≥ 75	Very high	32	3
			1030	100



Maps: lake catchments



Other data: explanatory variables



- P from livestock
 - Cattle, sheep – CSO Ag census and annual surveys
 - Pigs – CSO by county; EPA for IPPC piggeries
 - Poultry – CSO by county
- Arable land - CSO Ag census and annual surveys
- 2006 census of population
 - Septic tanks, population – rural & urban
- Corine 2006: forestry
- GIS data lake catchment characteristics
 - UWWT, geology, slope

Panel Regression

Regression

	Linear Model			Non-linear Model		
	Parameter Estimate	Standard Error		Parameter Estimate	Standard Error	
LnSepticTanks	0.157	0.081	*	0.152	0.082	*
UrbanCatch:6550	0.501	0.192	**	0.447	0.234	
UrbanCatch:30665	-0.723	0.202	**	-0.841	0.201	**
UrbanCatch:36657	1.565	0.152	**	1.694	0.161	**
UrbanCatch:36672	-0.354	0.147	**	-0.538	0.156	**
LnUrbanPop	0.287	0.079	**	1.758	0.635	**
LnUrbanPop ²				-0.092	0.038	**
Rural#UWWT 0#1	0.122	0.183		-0.008	0.197	
Rural#UWWT 1#0	2.129	0.589	**	7.933	2.580	**
Rural#UWWT 1#1	2.811	0.715	**	8.502	2.537	**
LncountyPigP	-0.114	0.023	**	-0.115	0.023	**
LnCountyPoultryPop	0.217	0.028	**	0.208	0.030	**
LnLivestockP	0.176	0.066	**	0.007	0.169	
LnLivestockP ²				0.012	0.011	
LnCatchArea	-0.419	0.102	**	-0.452	0.117	**
Forest06_den	0.079	0.045	*	0.073	0.045	
Ploughed_den	0.482	0.163	**	0.590	0.176	**
HighRainfall	-0.342	0.131	**	-0.317	0.138	**
SlopeDum	-0.293	0.159	*	-0.257	0.167	
s_aRend_Lith_Den	-1.678	0.958	*	-2.022	0.957	**
s_aPodzolics_Den	-2.945	0.707	**	-3.212	0.717	**
aRock_sediment_Den	-1.305	0.630	**	-1.321	0.612	**
aRock_metamorphic_Den	-5.599	1.353	**	-5.619	1.323	**
aRock_ignesis_Den	-6.154	1.584	**	-5.934	1.653	**
Constant	0.094	0.855		-4.708	2.831	*



Results: Septic tanks

LnSepticTanks .152

1% increase in number of septic tanks increases max chlorophyll reading by 0.15%.

Withers et al. (2012) septic tanks significant issue when discharged directly to stream network

95% CI: -.03 - .33



Photo: flickr.com/photos/lebrionnaise/2558469648/



Results: Urban Population

LnUrbanPop 1.76
LnUrbanPop² -0.09

Urban Population	Elasticity	Standard Error	
602	0.584	0.168	**
992	0.492	0.138	**
1,998	0.363	0.106	**
2,981	0.290	0.096	**
4,915	0.198	0.096	**
13,360	0.014	0.135	
18,034	-0.041	0.152	
73,130	-0.298	0.245	



Photo: flickr.com/photos/informatique/2744782929/

Results: UWWT Discharge

Rural#UWWTDischarge
0 1 | -.008
1 0 | 7.93
1 1 | 8.50

- Rural & UWWT << Rural & No UWWT
- Rural << Urban



Photo: flickr.com/photos/schahanelibrary/4578617093/

Results: Towns

6550	.447
36657	1.694
30665	-.841
36672	-.538

Lough Naglack
Lough Oughter
Lough Mask
Lough Erne



Photo: flickr.com/photos/scary_mary/3409616005



Results: Poultry

LnCountyPoultryPop .208

Significant effect but
doesn't have a practical
interpretation.



Photo: flickr.com/photos/ciwt/3218231674/



Results: Pigs – non-IPPC

LncountyPigP -.115

Variable measures pigs from county not just catchment. Estimate significant but doesn't have a practical interpretation & it's negative.



Photo: flickr.com/photos/93887247@N00/6624559303/

Results: Livestock

LnLivestockP .007

LnLivestockP² .012

Livestock P (tonnes)	Elasticity	Standard Error	
12	0.066	0.119	
148	0.125	0.078	
1,808	0.184	0.070	**
22,026	0.243	0.101	**
268,337	0.303	0.148	**
1,468,864	0.343	0.184	*
5,389,698	0.374	0.212	*



Photo: flickr.com/photos/nsalt/2808153695/

Results: Forestry

Forest06_den .073

100 basis point increase
forestry, 0.07% increase
in max chlorophyll.
Significant in linear
model

Gibson (1976): high phosphorus
concentration in afforested
upland lakes



Photo: curtisimages.com



Results: Arable Land

Ploughed_den .590

100 basis point increase in
arable land, 0.59%
increase in max
chlorophyll

Alternative is to use estimate of P
application by crop instead of
ploughed area



Photo: flickr.com/photos/stillburning/211910574



Summary



- Clear findings on agriculture, septic tanks, UWWT, forestry. Confirms existing knowledge
- New estimates of impact of discharges to the environment
- Not all sources accounted for, pigs, poultry, industry
- Info for catchment basis decision making

