Mant, R. & Pullin, A.S. 2012. What is the impact of 'liming' lakes on the abundance and diversity of lake biota? CEE review 11-003. Collaboration for Environmental Evidence: www.environmentalevidence.org/SR11003.html.

Appendix A: Details of searches carried out

Searches on 9/5/11

Web of science:

TS= ((Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (liming OR lime* OR chalk* OR 'calcium carbonate' OR dolomite) AND (Fish* OR Salmo* OR Trout OR Roach OR rutilus OR charr OR salvelinus OR Perch OR Pike OR Invert* OR Macroinvertebrate* OR macrofauna OR meiofauna OR zooplankton OR crustacea* OR microcrustacea* OR daphnia OR insect* OR Ephemeroptera OR Plecoptera OR Trichoptera OR coleopteran OR chironomid OR Mollus* OR bivalve* OR gastropod OR phytoplankton OR diatom* OR cyanobacteria OR Macrophyte*))

Hits = 550

Web of knowledge

Topic=((Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn)) AND Topic=(liming OR lime* OR chalk* OR 'calcium carbonate' OR dolomite) AND Topic=(Fish* OR Salmo* OR Trout OR Roach OR rutilus OR charr OR salvelinus OR Perch OR Pike OR Invert* OR Macroinvertebrate* OR macrofauna OR meiofauna OR zooplankton OR crustacea* OR microcrustacea* OR daphnia OR insect* OR Ephemeroptera OR Plecoptera OR Trichoptera OR coleopteran OR chironomid OR Mollus* OR bivalve* OR gastropod OR phytoplankton OR diatom* OR cyanobacteria OR Macrophyte*)

Timespan=All Years

Hits = 1527

Science Direct

tak ((Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (liming OR lime* OR chalk* OR "calcium carbonate" OR dolomite) AND (Fish* OR Salmo* OR Trout OR Roach OR rutilus OR charr OR salvelinus OR Perch OR Pike OR Invert* OR Macroinvertebrate* OR macrofauna OR meiofauna OR zooplankton OR crustacea* OR microcrustacea* OR daphnia OR insect* OR Ephemeroptera OR Plecoptera OR Trichoptera OR coleopteran OR chironomid OR Mollus* OR bivalve* OR gastropod OR phytoplankton OR diatom* OR cyanobacteria OR Macrophyte*))

Hits = 51

tak – searches in title, abstract and key words

CAB Abstracts
(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (liming OR lime* OR chalk* OR "calcium carbonate" OR dolomite) AND (Fish* OR Salmo* OR Trout OR Roach OR rutilus OR charr OR salvelinus OR Perch OR Pike OR Invert* OR Macroinvertebrate* OR macrofauna OR meiofauna OR zooplankton OR crustacea* OR microcrustacea* OR daphnia OR insect* OR Ephemeroptera OR Plecoptera OR Trichoptera OR coleopteran OR chironomid OR Mollus* OR bivalve* OR gastropod OR phytoplankton OR diatom* OR cyanobacteria OR Macrophyte*)
Hits=1576

ConservationEvidence.com
Searched for: liming OR lime OR chalk OR calcium carbonate OR dolomite
Cannot download so scanned through titles and downloaded relevant ones.
In Keywords: Hits = 48 Downloaded = 2
In Title: Hits =24 Downloaded = 0

Index to Theses Online http://www.theses.com
(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (liming OR lime* OR chalk* OR 'calcium carbonate' OR dolomite)
Cannot download so went through titles/abstract online and downloaded relevant ones.
Hits 178 downloaded: 1

Directory of Open Access Journals
Cannot carry out a complex search – max of two search terms
Searches:

Lake +	liming – 2	loch +	lime* - 1
	lime* - 2		liming – 0
	chalk* - 1		chalk* - 0
	calcium carbonate – 0		calcium carbonate – 0
	dolomite- 7	pond +	liming – 1
Catchment +	liming – 1		lime* - 3
	lime* - 2		chalk* - 0
	chalk* - 4		calcium carbonate – 0

	calcium carbonate – 1 dolomite- 2	dolomite- 0
Watershed +	liming – 1 lime* - 1 chalk* - 0 calcium carbonate – 0 dolomite- 2	llyn, mere and tarn were also combined with each of - liming OR lime* OR chalk* OR "calcium carbonate" OR dolomite but no hits were retrieved

CSA Illumina (Aqualine, ASFA1, ASFA3, Biology Digest, BioOne, Conference papers Abstracts, Ecology Abstracts, Pollution Abstracts)
(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (liming OR lime* OR chalk* OR "calcium carbonate" OR dolomite) AND (Fish* OR Salmo* OR Trout OR Roach OR rutilus OR charr OR salvelinus OR Perch OR Pike OR Invert* OR Macroinvertebrate* OR macrofauna OR meiofauna OR zooplankton OR crustacea* OR microcrustacea* OR daphnia OR insect* OR Ephemeroptera OR Plecoptera OR Trichoptera OR coleopteran OR chironomid OR Mollus* OR bivalve* OR gastropod OR phytoplankton OR diatom* OR cyanobacteria OR Macrophyte*)
Within Natural sciences
Hits 2124 without duplicates 1771

10/5/11

Agricola
Article citation database
(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (liming OR lime? OR chalk? OR dolomite) AND (Fish ? OR Salmo? OR Trout OR Roach OR rutilus OR charr OR salvelinus OR Perch OR Pike OR Invert? OR Macroinvertebrate? OR macrofauna O R meiofauna OR zooplankton OR crustacea? OR microcrustacea? OR daphnia OR insect? OR Ephemeroptera) Search Results: 37 entries.

(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (liming OR lime? OR chalk? OR dolomite) AND (Plec optera OR Trichoptera OR coleopteran OR chironomid OR Mollus? OR bivalve? OR gastropod OR phytoplankton OR diatom? OR cyanobacteria OR Macrophyte?) Search Results: 16 entries.

(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND ("calcium carbonate") AND (Plecoptera OR Trichopter a OR coleopteran OR chironomid OR Mollus? OR bivalve? OR gastropod OR phytoplankton OR diatom? OR cyanobacteria OR Macrophyte?) Search Results: Displaying 2 entries.

(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (calcium carbonate) AND (Fish? OR Salmo? OR Trout OR Roach OR rutilus OR charr OR salvelinus OR Perch OR Pike OR Invert? OR Macroinvertebrate? OR macrofauna OR meiofauna OR zooplankton OR crustacea? OR microcrustacea? OR daphnia OR insect? OR Ephemeroptera) Search Results: 3 entries.

Book search
Search Request: Command =
(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (liming OR lime? OR chalk? OR dolomite) AND (Fish ? OR Salmo? OR Trout OR Roach OR rutilus OR charr OR salvelinus OR Perch OR Pike OR Invert? OR Macroinvertebrate? OR macrofauna O R meiofauna OR zooplankton OR crustacea? OR microcrustacea? OR daphnia OR insect? OR Ephemeroptera) Search Results: 5

(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (liming OR lime? OR chalk? OR dolomite) AND (Plec optera OR Trichoptera OR coleopteran OR chironomid OR Mollus? OR bivalve? OR gastropod OR phytoplankton OR diatom? OR cyanobacteria OR Macrophyte?) Search Results: 0 entries.

(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND ("calcium carbonate") AND (Plecoptera OR Trichopter a OR coleopteran OR chironomid OR Mollus? OR bivalve? OR gastropod OR phytoplankton OR diatom? OR cyanobacteria OR Macrophyte?) Search Results: Displaying 0 entries.

(Lake OR Catchment OR watershed OR loch OR pond OR llyn OR mere OR tarn) AND (calcium carbonate) AND (Fish? OR Salmo? OR Trout OR Roach OR rutilus OR charr OR
salvelinus OR Perch OR Pike OR Invert? OR Macroinvertebrate? OR macrofauna OR meiofauna OR zooplankton OR crustacea? OR microcrust acea? OR daphnia OR insect? OR Ephemeroptera) 0 hits

Copac
Will not allow complex searches so search had to be adapted.
Lake liming – 4 Catchment liming – 8
Watershed liming – 2 Loch liming – 3
Pond/llyn/mere/tarn liming – no hits
Lime* lake – 36991 none of the first 50 relevant at all – about limerick in Ireland, music, or other non-scientific/environmental books so search not included
Limed lake – no hits Lime lakes – 9 hits but none of which were relevant
Chalk* lake – 28563 hits, none of first 50 relevant: mainly music related books: so search not used

Chalk lake – 6 hits but none relevant
Calcium carbonate lake - no hits Dolomite lake – 1 hit but not relevant

So restricted copac search to liming and lake/catchment ect

Appendix B: Details of papers excluded at full text

Papers that could not be obtained:

Anon (1991). International lake and watershed liming practices /. Washington, D.C. :, Terrene Institute, Electric Power Research Institute., U.S. Fish and Wildlife Service. Living Lakes, Inc.

Alenaes, I. (1986). "Liming Project Haerskogen 1976-1986: Water Chemical and Biologic Response on Liming in Seven West Swedish Lakes (Kalkningsprojektet Harskogen 1976-1986: Vattenkemisk och Bilogisk Respons pa kalkningsatgarder i sju Vastsvenska Sjoar)."

Appelberg, M. (1990). "Population regulation of the crayfish Astacus astacus L. after liming an oligotrophic, low-alkaline forest lake." Limnologica 20(2): 319-327.

Appelberg, M. (1992). "Liming as a measure to restore crayfish populations in acidified lakes." Finnish Fisheries Research 14(0): 93-105.

Brodin, Y. W. and L. Henrikson (1998). "Restoration of acidified freshwaters by liming." International Association of Theoretical and Applied Limnology, Proceedings - Vol 26, Pt 5 26: 2405-2407

Bukaveckas, P. A. (1988). "Effects of calcite treatment on primary producers in acidified Adirondack lakes - response of macrophyte communities." Lake and Reservoir Management 4(1): 107-113.

Coahran, D. A., D. J. Orth, et al. (1988). "Liming acid-sensitive lakes: the Flat Top experience." Virginia Journal of Science 39: 149.

Ejsmont-Karabin, J. (1996). "Long-term changes in the abundance and structure of the community of planktonic rotifera in a humic lake, as a result of liming." Ekologia Polska 44(1-2): 39-51.

Grinstead, B. G., W. P. Ebaugh, et al. (1991). "Enhancing sport fish production in seepage lakes of the Ocala National Forest in central Florida." Usda Forest Serv., Washington, Dc.

Hasselrot, B. and H. Hultberg (1984). "Liming of Acidified Swedish Lakes and Streams and Its Consequences for Aquatic Ecosystems." Fisheries 9(1): 4-9.

Henrikson, L., H. G. Nyman, et al. (1982). "How to utilize limed lakes: the Swedish Society of Limnology Annual Conference, Goteborg, 1982." Vatten 38(4): 416-430.

Henrikson, L., H. G. Nyman, et al. (1985). "Changes in the zooplankton community after lime treatment of an acidified lake." Internationale Vereinigung fuer Theoretische und Angewandte Limnologie Verhandlungen 22(5): 3008-3013.

Hillbrichtilkowska, A., J. I. Rybak, et al. (1977). "Effect of liming on a humic lake." Ekologia Polska-Polish Journal of Ecology 25(3): 379-420

Hillbricht-Ilkowska, A., K. Dusoge, et al. (1998). "Long term effects of liming in a humic lake: Ecosystem processes, biodiversity, food web functioning (Lake Flosek, Masurian Lakeland, Poland)." Polish Journal of Ecology 46(4): 347-415

Hillbricht-Ilkowska, A., Y. A. Rybak, et al. (1977). "Reaction of 2 dystrophic lakes to liming and fertilizer." Gidrobiologicheskii Zhurnal 13(6): 39-45

Ives, A. R., T. M. Frost, et al. (2006). "Insights on community dynamics from large-scale, long-term data: Time series for zooplankton and environmental variates from 35 North American lakes."

Johnson, R. K. (2006). "Assessing the recovery of sublittoral macroinvertebrate communities of boreal lakes from the effects of acidic deposition and liming." International Association of Theoretical and Applied Limnology, Vol 29, Pt 3, Proceedings 29: 1383-1388
Johnson, R. K. and O. Hoffrichter (2000). "Long-term responses of macroinvertebrate communities to liming." Late 20th Century research on Chironomidae. An anthology from the 13th International Symposium on Chironomidae, Freiburg, 5-9 September 1997.: 463-470
Kauppi, P., P. Anttila, et al. (1990). "ACIDIFICATION IN FINLAND." Kauppi, P., P. Anttila and K. Kenttamies (Ed.). Acidification in Finland. Springer-Verlag New York, Inc.: Secaucus, New Jersey, USA; Berlin, Germany.
Kharitonova, N. N. and L. V. Gorobets (1980). "Effect of liming of intensively exploited ponds on the development of phyto plankton." Gidrobiologicheskii Zhurnal 16(4): 46-51.
Kleiven, S. and A. Lande (2000). "Effects of liming in mountain lakes." International Association of Theoretical and Applied Limnology, Vol 27, Pt 1, Proceedings 27: 489-493.
Kleiven, S. and A. Lande (2005). "Effects of liming on phyto- and zooplankton communities in mountain lakes." International Association of Theoretical and Applied Limnology, Vol 29, Pt 2, Proceedings 29: 802-806.
Kretser, W. A. and J. R. Colquhoun (1984). "Treatment of New York 's Adirondack Lakes by Liming." Fisheries 9(1): 36-41.
Kuoppamaki, K. (1993). "Effects of liming on crustacean zooplankton in an acidified, artificially divided forest lake in southern finland." International Association of Theoretical and Applied Limnology - Proceedings, Vol 25, Pt 1 25: 529-533.
Lindstrom, T. (1998). "Short-term changes of crustacean plankton reproduction and juvenile survival in some acidified and limed high mountain lakes." Nordic Journal of Freshwater Research 74: 127-140.
Nilssen, J. P. and S. B. Waervagen (2002). "Recent re-establishment of the key species Daphnia longispina and cladoceran community changes following chemical recovery in a strongly acid-stressed region in southern Norway." Archiv Fur Hydrobiologie 153(4): 557-580.
Nyberg, P. (1988). "Reclamation of acidified Arctic char (Salvelinus alpinus L.) lakes in Sweden by means of liming." Proceedings. International Association of Theoretical and Applied Limnology 23: 1737-1742
Olem, H., I. Electrical Power Research, et al. (1991). International lake and watershed liming practices: International liming symposium : Papers. Washington DC, Terrene Institute
Olofsson, H., P. Blomqvist, et al. (1988). "Restoration of the pelagic food web in acidified and limed lakes by gentle fertilization." Limnologica 19(1): 27-36.
Pamatmat, M. M. (1974). "Alkalinity, hardness, and productivity of limed ponds." Journal of Marine Science of Alabama 2(3): 95-110.
Raddum, G. G., et al. (1997). "History of acidification and restoration of the fauna in Lake Nordre Boksjo." International Association of Theoretical and Applied Limnology, Vol 26, Pt 2 26: 760-764.
Raitaniemi, J., M. Rask, et al. (1994). "Observations on the development of fish populations in small acidified lakes in southern Finland during a four-year period after liming." Sublethal and chronic effects of pollutants on freshwater fish.: 326-336.
Rask, M. and J. Raitaniemi (1990). "Preliminary Observations on the Effects of Liming to the Fish Populations of Small Acidic Lakes in Southern Finland." Aqua Fennica AQFEDI 20(1): 115-123.

Round, F. E. (1990). "The effect of liming on the benthic diatom populations in three upland welsh lakes wales uk." Diatom Research 5(1): 129-140.
Schofield, C. L., S. P. Gloss, et al. (1989). "Production and growth efficiency of brook trout (Salvelinus fontinalis) in two Adirondack mountain (New York) lakes following liming." Canadian Journal of Fisheries and Aquatic Sciences 46(3): 333-341.
Shortelle, A. B. and E. A. Colburn (1987). "Ecological Effects of Liming in a Cape Cod Kettle Pond: a Note for Fisheries Managers." Lake and Reservoir Management 3(436): 436-443.
Siegfried, C. A., J. W. Sutherland, et al. (1987). "Plankton Community Response to the Chemical Neutralization of Three Acidified Waters in the Adirondack Mountain Region of New York State." Lake and Reservoir Management 3(444).
Smith, B. B. and C. B. Reif (1991). "Microscopic flora and fauna of bear lake pennsylvania 1985-1989." Journal of the Pennsylvania Academy of Science 65(2): 75-79.bl
Sosnowska, J. (1990). "The effect of liming of fish ponds on the development of phytoplankton." Polskie Archiwum Hydrobiologii 37(4): 479-494.bl
Strong, K. W. (1987). "The effect of lime on the zooplankton population of sandy lake halifax county nova scotia canada." Proceedings of the Nova Scotian Institute of Science 37(2): 63-70.
Underwood, J., A. P. Donald, et al. (1987). "Investigations into the use of limestone to combat acidification in 2 lakes in west wales." Journal of Environmental Management 24(1): 29-40.
White, W. J., W. D. Watt, et al. (1984). "Experiment on the Feasibility of Rehabilitating Acidified Atlantic Salmon Habitat in Nova Scotia by the Addition of Lime." Fisheries 9(1): 25-30.
Willen, E. (2006). "Planktonic algae in limed lakes compared to circumneutral references." International Association of Theoretical and Applied Limnology, Vol 29, Pt 5 29: 2232-2236

Non-English language papers:
Norwegian language papers

Andersen, R. (1994). "Re-establishing of piscivorus brown trout as a result of partial lake liming." Fauna (Oslo) 47(1): 52-59.
Barlaup, B. T. (2004). "Vannkjemisk og biologisk utvikling i i innsjøen Vegår i Aust-Agder etter 17 år med kalking." Utredning 2004-4.
Bjerknes, V., et al. (2004). "Innsjøundersøkelse i Sogn og Fjordane 2003 Vannkvalitet, kalkingseffekter, fisk, bunndyr og dyreplankton." Norsk institutt for vannforskning (NIVA); 2004;
Brandrud, T. E. (1999). "Undersøkelse av vannvegetasjon i forsurete/kalkete lokaliteter i Hordaland i 1996-97: Eksingedalsvassdraget i Vaksdal, Frølandsvatn i Samnanger og Havsgårdsvatn i Fusa." Norsk institutt for vannforskning (NIVA); 1999; 23

Brandrud, T. E. (2000). "Effekter av forsuring og kalking på makrovegetasjon i vann. En kunnskapsstatus." DN-utredning 6-2000, Utredning 2000-72
Brandrud, T. E., P. Brettum, et al. (2000). "Effekter av kalking på biologisk mangfold." DN-utredning 4-2000
Hesthagen, T. and R. Saksgård (2000). "Effekt på kalking på fiskebestander i innsjøer med vekt på røye." NINA Oppdragsmelding 643: 1-18.
Hesthagen, T. H., B. Walseng, et al. (2002). "Effekter av forsuring og kalking på fisk og krepsdyr i innsjøer i Enningdalsvassdraget, Østfold." Kilde
Hobæk, A., V. Bjerknes, et al. (1995). "Evaluering av fullkalkete innsjøer i Sogn og Fjordane: Fiskebestander, makrovegetasjon, bunndyr og dyreplankton." Norsk institutt for vannforskning (NIVA); ; 81
Johansen, S. W. (2005). "Effekter av kalking på vannvegetasjon/krypsiv-tilgroing. Reundersøkelse av kalkede og ikke kalkede innsjøer i 2003" NIVA; 2005; 36. Norwegian Institute for Water Research
Johnsen, S. I., B. K. Dervo, et al. (2009). "Effekter av kalking på vannkvalitet, dyreplankton, bunndyr, fisk og fritidsfiske i Buskerud 1997-2007." NINA Rapport 420: 43 pp. Norsk institutt for naturforskning (NINA), Lillehammer.
Kaste, Ø., P. Brettum, et al. (1999). "Store Finntjenn i Aust-Agder. Vannkjemisk og biologisk utvikling i løpet av 15 år med kalking." Norsk institutt for vannforskning (NIVA); 1999; 74 s.
Kleiven, E. (1999). "Kalkingsresponsar på ulike fiskeartar i Vestre og Austre Grimevatn, Lillesand, og historia om lagesilda (Coregonus albula) på Sørlandet (" Norsk institutt for vannforskning (NIVA); 1999; 55 s.
Kleiven, E. and A. N. Linlokken (2009). "Comparison of age determination on opercular bones and burned otoliths of perch Perca fluviatilis from five lakes at Fjorda, Oppland." Fauna (Oslo) 62(4): 112-123.
Kleiven, E. and B. T. Barlaup (2004). "Fiskebestandane i Syndle og Vigelandsvatn, Aust-Agder - frå sterkt forsuringskadde til tette bestander etter kalking." Norsk institutt for vannforskning (NIVA); 2004; 38 s.
Kleiven, E. and B. T. Barlaup (2005). "Discovery of spawning sites for the smelt Osmerus eperlanus in Lake Vegar - Aust-Agder." Fauna (Oslo) 58(3): 86-90.bl
Kleiven, E. and J. Håvardstun (1997). "Fiskebiologiske effektar av kalking i 50 innsjøar (Fishery effects of liming in 50 lakes)." Norsk institutt for vannforskning (NIVA); 1997; 174 s.
Kleiven, E., Håvardstun, et al. (2007). "Prøvefiske i 2005 i Grindheimsvannet, Øvre Øydnavatnet og Ytre Øydnavatnet, Vest-Agder, i samband med kalking." NIVA; 2007; 30 s.
Kleiven, S., A. Lande, et al. (2002). "Effekter av kalking på fjellvann." Utredning 2002-4.
Lindstrøm, E.-A. (2005). "Effekter av kalking på biologisk mangfold." DN-utredning 5-2005
Lindstrøm, E.-A., P. Brettum, et al. (2004). "Vannvegetasjon i norske vassdrag Kritiske grenseverdier for forsuring. Effekter av kalking " Norsk institutt for vannforskning (NIVA); 2004; 133 s.
Taugbøl, T. (2005). "Effekter av kalking på forsuringsrammede krepsebestander (Overvåking av 5 lokaliteter i Hedmark over en 10-15 års periode)." NINA Rapport 98: 50 pp.

Walseng, B. and L. R. Karlsen (1997). "Reetablering av forsuringsfølsomme invertebrater etter kalking av ferskvann i Østfold" NINA Oppdragsmelding 490: 1-32.y

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Dahlberg, M. (2000). "Results from the test-fishing 1999 - an evaluation of environmental monitoring in 39 lakes using fish communities as indicators." Finfo Fiskeriverket Informerar 2: Unpaginated.
Dahlberg, M. (2001). "Results from the Freshwater Laboratory fish samples in 2000." Finfo Fiskeriverket Informerar 4: Unpaginated.
Dahlberg, M. (2002). "Result from the Freshwater Laboratory project on experimental fish 2001. Annual report for 2001." Finfo Fiskeriverket Informerar 4: 1-35
Dahlberg, M. (2004). "Result from the Freshwater Research Laboratory test fishing in lakes during 2003." Finfo Fiskeriverket Informerar 3: 1-77, 1-32.
Eriksson, F. (1988). "Macrophyte vegetation in limed lakes." Information fraan Soetvattenslaboratoriet, Drottningholm 9
Eriksson, M. O. G. (1987). "The production of young in black-throated diver, Gavia arctica, in south-west Sweden." Var Fagelvarld 46(4): 172-186.
Holmgren, K., A. Kinnerback, et al. (2007). "Basis for the assessment of the fish fauna status in lakes. Development and application of EQR8." Finfo Fiskeriverket Informerar 3: 1-52.
Lindstroem, T. (1992). "Zooplankton in 1976-91, the Fulufjaell district, the southern high mountain." Inf. Soetvattenslab. Drottningholm. no. 2: 35-68.
Nyberg, P., E. Degerman, et al. (1986). "Acid-sensitive Arctic char (Salvelinus alpinus) lakes in southern and central Sweden." Information fraan Soetvattenslaboratoriet, Drottningholm

Russian language papers

Abrosov, V. N. (1963). "Theoretical reasons for the conversion of acid lakes into eutrophic ones Engl. summ. From: REF ZH BIOL, 1965, No. 2D280. (Translation)." Ev Gos Nauch Esled Inst Ozern Rechn Rybn Khoz 55: 60-69.
Krazhan, S. A., T. G. Litvinova, et al. (1990). "The development of phyto- and zooplankton in rearing ponds of various trophic conditions through the introduction of mineral fertilization and liming." Rybnoe Khozyaistvo Respublikanskii Mezhvedomstvennyi Tematicheskii Nauchnyi Sbornik: 39-43.

German language papers

Soechtig, W. (1989). "The influence of lime fertilizations on the benthic macrofauna of Oberer Grumbacher Teich near Hahnenklee-Bockswiese (Harz Mountains)." Braunschweiger Naturkundliche Schriften.

Finnish language papers

Iivonen, P. and K. Kenttämies (1995). "Happamoituneiden vesistöjen kalkitus Suomessa = Referat: Kalkning av försurade vattendrag i Finland" Helsinki : Vesi- ja ympäristöhallitus, 1995

Japanese language papers

Imada, K., T. Ito, et al. (1989). "Environmental changes of Lake Toya, with particular references on its acidification and neutralization." Scientific Reports of the Hokkaido Fish Hatchery: 65-75.

Papers not relevant to the review (reason)

Anon (1975). "Lime requirement and application in fish ponds." FAO, Rome 6. (aquaculture, impact on water chemistry)
Anon (1987). "Aquatic Effects (Napap Annual Report 1986)." NAPAP Report 111. (have an article of liming experiments mentioned in abstract separately)
Anon (1988). "Lake Acidification Mitigation." Electric Power Research Institute Journal 13(5).(The impact of liming on biota from this study reported in other articles and cannot get hold of this article)
Anon (1988). "Liming Research Program." Lake Line 8(3). (have papers on final results of the study)
Anon. (1990). "Acid Waters in Wales." Monographiae Biologicae 66. (review, no data on the impact of liming on biota)
Anon. (1995). "Liming of acidified lakes and rivers in Norway: A presentation of the Norwegian liming programme and of an integrated project in the Tovdalselva water system." Lake and Reservoir Management 11(2).(abstract only, as from conference proceedings special issue, have latest report on catchment mentioned)
Anon. (1995). "Recovery of fish and invertebrates in acidified Lake Hovvatn after 14 years of liming." Lake and Reservoir Management 11(2).(abstract only (conference proceedings), have other full articles on lake)
Anon. (1995). "Restructuring of fish communities following amelioration of acid stress through liming." Lake and Reservoir Management 11(2). (abstract only, conference proceedings)
Anon. (1995). "The potential for lake trout lakes to recover from acidification." Lake and Reservoir Management 11(2).(review - have primary papers on places mentioned)
Anon. (2010). "Pond Fertilization and Liming." from http://warnell.forestry.uga.edu/service/library/index.php3?docID=44&docHistory%5B%5D=1. (overview, no primary data)
Abrahamsen, H. and D. Matzow (1981). "Use of Lime Slurry for Deacidification of Running Water." Verhandlung Internationale Vereinigung Limnologie 22(3): 1981-1985. (impact on rivers only)

Abrosov, V. N. and N. A. Zabegalina (1963). "The hydrochemical change in Lake Okunevets under the action of liming and fertilizing Engl. summ. From: REF ZH BIOL, 1964, No. 12D266. (Translation)." Izv Gos Nauch Issled Inst Ozern Rechn Rybn Khoz 55: 38-46. (liming and fertilizer together)
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Havens, K. E. (1999). "Correlation is not causation a case study of fisheries, trophic state and acidity in Florida (USA) lakes." Environmental Pollution 106(1): 1-4. (no primary data on impact of liming on biota)
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Hendrey, G. R. (1982). "Effects of acidification on aquatic primary producers and decomposers." Acid Rain/Fisheries: Proceedings of International Symposium. Cornell University, Bethesda, Md 135(15Aa HAI). (acidification not liming)
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Henrikson, L., A. Hindar, et al. (1995). "Freshwater liming." Water Air and Soil Pollution 85(1): 131-142. (review)
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Hindar, A. and B. O. Rosseland (1988). "Liming Acidic Waters in Norway: National Policy and Research and Development." Water, Air, and Soil Pollution 41(1-4): 17-24. (details of the Norwegian liming program, how it developed and it's extent rather than data of the impact on biota)
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Howells, G. (1987). "The Loch Fleet Project: restoring trout to an acid lake." Salmon and Trout Magazine. no. 234: 34-39. (report of project detailed results on biota presented elsewhere)
Howells, G. and D. J. A. Brown (1992). Acidification and Liming in Context. Restoring Acid Waters: Loch Fleet 1984-1990: 3-19. (introduction to project, data on biota in other chapter of book)
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Howells, G. D. and D. J. A. Brown (1986). "Loch Fleet: techniques for acidity mitigation." Water, Air, & Soil Pollution 31(3): 817-825. (only pre liming data)
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Hutorowicz, A., A. Kapusta, et al. (2005). "The ichthyofauna of the dystrophic Lake Smolak (northern Poland) in light of selected physical and chemical water conditions thirty years after the conclusion of liming and fertilization." Archives of Polish fisheries/Archiwum rybactwa polskiego 13(2): 207-225. (only data on post liming reacidifcation stage)

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Jones, C. (1989). "Mitigating acid-precipitation damage using liming." Water Environment & Technology 1(2). (have later papers on the impact of the liming program on the lake)
Kann, E. (1982). "The littoral algal vegetation of the Zeller See (Salzburg, Osterreich)." Archiv Fur Hydrobiologie 94(4): 492-501. (no data on liming, just mentions lake is 'medium rich in lime')
Kappes, H. and U. Sinsch (2005). "Tolerance of Ceriodaphnia quadrangula and Diaphanosoma brachyurum (Crustacea: Cladocera) to Experimental Soft Water Acidification." Hydrobiologia 534: 109. (data on experimental acidification, not liming despite lake being limed before start of experiments)
Karatayev, A. Y., L. E. Burlakova, et al. (2008). "Community analysis of Belarusian lakes: correlations of species diversity with hydrochemistry." Hydrobiologia 605: 99-112. (liming not looked at)
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Larsson, S. (1995). "The effects of liming on aquatic flora." Liming of acidified surface waters: A Swedish synthesis: 193-220. (review)
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Vladimirova, T. M. (1962). "The zooplankton of Zemchuzhnoe Lake and its use as affected by polychloropinene and mineral fertilizers From REF ZH BIOL, 1964, No. 2D260. (Translation)." Nauch Tekh Byul Gos Nauch Issled Inst Ozern Rechn Rybn Khoz 16: 29-32. (multiple treatments not just liming.)
Vrede, K. (1999). "Effects of inorganic nutrients and zooplankton on the growth of heterotrophic bacterioplankton -- enclosure experiments in an oligotrophic clearwater lake." Aquatic Microbial Ecology 18(2): 133-144. (abundance of phyto and zooplankton in small-scale manipulation experiments, no data on whole lake abundances with and without liming)
Vuorinen, P. J., S. Peuranen, et al. (2004). "Acute effects on perch (Perca fluviatilis) and long-term effects on whitefish (Coregonus lavaretus pallasi) of liming of an acidified lake." Journal of Applied Ichthyology 20(3): 217-224. (physiology, no data on abundance or diversity of fish)

Wällstedt, T., F. Edberg, et al. (2009). "Long-term water chemical trends in two Swedish lakes after termination of liming." The Science of the total environment, 407(11): 3554-3562. (no data on biota)
Walseng, B. "Plankton versus littoral microcrustaceans (copepods and cladocerans) as indicators of recovery from acidification." Congress in Melbourne 2001, Proceedings. Verhandlungen. Internationale Vereinigung fur theoretische und angewandte Limnologie/Proceedings. International Association of Theoretical and Applied Limnology/Travaux. Association internationale de Limnologie theorique et appliquee 28, no. (no new primary data on biota)
Walseng, B. and L. R. Karlsen (2009). "Endring i krepsdyr- og fiskefaunaen etter kalking i syv vann i Østfold." NINA Rapport 469: 47 pp. Norsk institutt for naturforskning (NINA), Oslo. (dulplicate)
Walseng, B. and L. R. Karlsen (2009). "Recovery of acid sensitive crustaceans and fish in seven
Warfvinge, P. Modeling acidification mitigation in watersheds Lund University (model and no data on biota)
Watanabe, T. (1984). "Advances in planktology in Japan and abroad in the last decade. Fresh-water plankton. 1. Distribution and ecology of fresh-water phytoplankters." Bulletin of the Plankton Society of Japan (not about liming to mitigate lake acidification)
Waters, T. F. (1957). "The Effects of Lime Application to Acid Bog Lakes in Northern Michigan." Transactions of the American Fisheries Society 86(1): 329-344. (liming to fertilize naturally acid pond not acidification mitigation)
Waters, T. F. and R. C. Ball (1957). "Lime application to a soft-water, unproductive lake in northern Michigan." Jour Wildlife Management 21((4)): 385-391. (liming to increase productivity not decrease acidificication)
Watt, W. D., G. J. Farmer, et al. (1984). "Studies on the Use of Limestone to Restore Atlantic Salmon Habitat in Acidified Rivers." EPA Lake and Reservoir Mgt Report 374. (only river biota data available)
Weatherley, N. S. (1988). "Liming to Mitigate Acidification in Freshwater Ecosystems: a Review of the Biological Consequences." Water Air and Soil Pollution 39(3). (review)
Weatherley, N. S., M. J. Jenkins, et al. (1995). "Options for liming rivers to ameliorate acidity - A UK perspective." Water Air and Soil Pollution 85(2): 1009-1014. (no primary data on impact on lake biota)
Weglen´ska, T. (1998). "Abundance and structure of planktonic crustacean community of a humic Lake Smolak twenty years after the experimental mineral fertilisation." Archiwum Rybactwa Polskiego 6(2): 219-232. (fertilization and liming at the same time)
Weigel, C. and A. Valdeyron (1993). "Maintenance: The contribution of calcium ameliorators." Aqua revue. Tours [AQUA REV.]. no. 50: 12-17. (aquaculture, review)
Wenblad, A. (1987). "Effects of Acidification on Fish in Scandinavia: an Overview." 12(4). (review)
Westling, O. and T. Zetterberg (2007). "Recovery of Acidified Streams in Forests Treated by Total Catchment Liming." Water, air & soil pollution 7(1-3): 347-356. (only stream data not lakes)
Wilander, A. "Acidification and effects of liming as revealed by national lake surveys in Sweden." (no data impact of liming on biota)
Wilander, A. and T. Ahl (1972). "The effects of lime treatment to a small lake in Bergslagen, Sweden." Vatten/Water. Stockholm 28(5): 431-445 (no data on biota, just chemical data)

Wilson, E. J., G. Hudson, et al. (1992). Soils of Acid Catchments Before and After Liming. Restoring Acid Waters: Loch Fleet 1984-1990: 199. (not impact of liming on biota, in other chapters of book)
Woodin, S. and U. Skiba (1990). "Liming fails the acid test." New Scientist 125(1707): 50-52. (review)
Wright, D., M. Danks, et al. "Short-term response of Thrush Lake, Minnesota, to lime addition." (have later articles detailing response of biota to the liming)
Wright, R. (1984). "Changes in the chemistry of Lake Hovvatn, Norway, following liming and reacidification." NIVA, Oslo; 1984; s, Minstry of the Environment. (chemistry only)
Wright, R. F. (1985). "Chemistry of Lake Hovvatn, Norway, Following Liming and Reacidification." Canadian Journal of Fisheries and Aquatic Sciences 42(6): 1102-1113. (chemistry only)
Wright, R. F. and O. K. Skogheim (1983). "Aluminum speciation at the interface of an acid stream and a limed lake." Vatten 39(3): 301-304. (archive only goes back to 1985, have other papers on this study)
Wrobel, S. (1963). "Chemical studies on fishponds in the Wojcza State Fisheries." Acta hydrobiol. Krakow. 5: 215-227. (no data on biota)
Yee, K. A., E. E. Prepas, et al. "Effects of lime additions on benthic macroinvertebrates in eutrophic hardwater lakes." Lake and Reservoir Management 9, no. (liming to mitigate eutrophication not acidification)
Yee, K. A., E. E. Prepas, et al. (2000). "Impact of Ca(OH)2 treatment on macroinvertebrate communities in eutrophic hardwater lakes in the Boreal Plain region of Alberta: in situ and laboratory experiments." Canadian Journal of Fisheries and Aquatic Sciences 57(1): 125-136. (liming to mitigate eutrophication not acidification)
Young, T. C., J. V. DePinto, et al. "Calcite Dose Selection, Treatment Efficiency, and Residual Calcite Fate After Whole-Lake Neutralization." Canadian Journal of Fisheries and Aquatic Sciences 46, (no data on biota)
Zdanowski, B. and A. Hutorowicz (1998). "Long-term effects of liming and fertilisation in an acidic dystrophic Lake Smolak (Mazurian Lakeland, Poland)." Archiwum rybactwa polskiego/Archives of Polish fisheries. Olsztyn 6(2): 159-185. (fertilization and liming at the same time)
Zeller, H. D. and A. B. Montgomery (1958). "Preliminary investigations of chemical soil and water relationships and lime treatment of soft water in Georgia farm ponds." Proc Ann Conf South Eastern Assoc Game and Fish Comm 11: 71-76. (aquaculture)

Zemlyanitsina, T., T. I. Artamonova, et al. (1987). "(The effect of environmental factors on the development of phytoplankton in ponds.)." Sbornik nauchnykh trudov Vserossijskogo nauchno issledovatel'skogo instituta prudovogo rybnogo khozyajstva. Moscow [SB. NAUCHN. TR. VNIIPRKH.]. (aquaculture)
Zengerle, M. W. and M. A. Allan (1987). "Status Reports on Selected Environmental Issues Liming of Acidified Waters." EPRI Report Ea 1. (review ()
Zhang, Y. and E. E. Prepas (1996). "Short-term effects of Ca(OH)(2) additions on phytoplankton biomass: A comparison of laboratory and in situ experiments." Water Research 30(5): 1285-1294. (liming to control eutrophication and algal blooms not acidification)

Zhang, Y., A. Ghadouani, et al. (2001). "Response of plankton communities to whole-lake Ca(OH) and CaCO additions in eutrophic hardwater lakes." Freshwater Biology 46(8): 1105-1119. (liming to reduce eutrophication and algal blooms not acidification)

Appendix C: Summary of articles reporting data on fish.

C.1 Studies giving quantitative data on fish abundance or richness

Study	Study Design	Liming /pH change	Results
Andersen, R. and L. A. Vollestad (1996). "Recovery of piscivorous brown trout and its prey, Arctic char, in the acidified Lake Selura after liming." Nordic Journal of Freshwater Research 72, pp.	BA, 1 lake Data from 1 year prior to large scale liming and 10 years during.	Shellsand deposited into streams and shellsand drums installed in 1984, 1985 additional large shellsand drum in tributary and yearly liming of lake directly started (small scale liming of tributaries had taken place before start of study with little, if any, effect) pH before monthly mean pH 4.9-5.0, after 5.6-6.0	Abundance (CPUE): Brown trout: Before (1yr: 1983, 2 sites) | After (10yrs: 1984-93, 2 sites) 2.2 (SD 0.6) | 6.1 (SD 4.6) Effect size (log ratio):1.00 (SE 2.06) Char Before (1yr: 1983, 2 sites) | After (10yrs: 1984-93, 2 sites) 0.07 (SD 0.09) | 0.32 (SD 0.42) Effect size (log ratio):1.55 (SE 6.37),
Appelberg, M. (1998). "Restructuring of Fish Assemblages in Swedish Lakes Following Amelioration of Acid Stress through Liming." Restoration Ecology 6(4): 343-352.	BA , 14 limed lakes Unclear how before data collected and if there was systematic and consistent sampling. After data taken from an average of 14years study.	Limed according to the Swedish national program by lake, wetland, doser or upstream of the lake. pH before liming lake averages' 4.3 to 5.7, after liming average 5.8 to 6.6, control average 4.4 to 5.5	Species richness: Mean number of species per lake Before liming | After liming 3.3 (SD1.9) | 3.9 (SD 1.6) Effect size (log ratio): 0.25 (SE 0.10) (averaged across lakes, paired analysis in paper states there is a significant difference ($p<0.05$)) Fish stocked in several lakes if stocked fish removed from species list Effect size (log ratio): 0.13 (SE 0.08) Acid reference lakes mean species number: Acid controls | 1.4 (SD 1.7) Effect size (log ratio), CI: 1.02 (SE 0.67)
Appelberg, M. (1995). "Liming strategies and effects: The Lake	BA, 1 lake	Lime applied directly to lake at irregular intervals (in 1985, 87, 88	Abundance: Perch (catch per unit effort, CPUE)

<table>
<tr>
<td>Gyslattasjon case study." Liming of acidified surface waters: A Swedish synthesis: 353-361.</td>
<td>Data from one sample before liming (1983) and 6 after liming (1987-93)

Roach and bream stocked in 1988</td>
<td>and 91)

pH before liming 4.8-6, after 5.6-7.2</td>
<td>
<table>
<tr><td>Before liming</td><td>After liming</td></tr>
<tr><td>25</td><td>14 (SD 4)</td></tr>
</table>
Effect size (log ratio): -0.54 (SE 0.18)
</td>
</tr>
<tr>
<td>Appelberg, M. (1995). "Liming strategies and effects: The Lake Stora Harsjon case study." Liming of acidified surface waters: A Swedish synthesis: 339-351.</td>
<td>BA, 1 lake

Data from three samples before liming (1973,76,77) and 4 after liming (1981, 84, 87, 89)</td>
<td>Lake limed directly, along with upstream lakes in Autumn 1977/spring 1978

pH 5 before liming to 6.7 – 7.2 after liming
Alkalinity rose from 0 to 0.16</td>
<td>Abundance:
Perch
<table>
<tr><td>Before</td><td>After</td></tr>
<tr><td>16 (SD 12)</td><td>15 (SD 8)</td></tr>
</table>
Effect size (log ratio): - 0.04 (SE 0.41)

Pike
<table>
<tr><td>Before</td><td>After</td></tr>
<tr><td>0.06 (SD 0.01)</td><td>0.08 (SD 0.06)</td></tr>
</table>
Effect size (log ratio): 0.36 (SE 0.77)

Roach
<table>
<tr><td>Before</td><td>After</td></tr>
<tr><td>0.03 (SD 0.05)</td><td>3.3 (SD 3.0)</td></tr>
</table>
Effect size (log ratio): 4.57 (SE 60.31)

Cisco/vendace
<table>
<tr><td>Before</td><td>After</td></tr>
<tr><td>1.3 (SD 1.8)</td><td>1.6 (SD 0.8)</td></tr>
</table>
Effect size (log ratio): 0.17 (SE 0.52)
</td>
</tr>
<tr>
<td>Bergquist, B. C. (1991). "Extinction and natural recolonization of fish in acidified and limed lakes." Nordic journal of freshwater research. Drottningholm. 66: 50-62.</td>
<td>BA study design
87 lakes,

Unclear exactly how long before and after liming were sampled.</td>
<td>Limed according to the Swedish national program. Details of each lake not given

pH before liming was below 6 in most lakes, after liming pH increased and the average was approximately 6.5</td>
<td>Species richness
Mean number of species in lakes
<table>
<tr><td>Before liming</td><td>After liming</td></tr>
<tr><td>3.6</td><td>4</td></tr>
</table>
Effect size (log ratio): 0.10
(errors in the means not presented but the difference is stated as being significant at p<0.001)</td>
</tr>
<tr>
<td>Degerman, E., M. Appelberg, et al. (1992). "Effects of liming on</td>
<td>BA study
103 lakes in</td>
<td>Liming by direct lake liming or catchment liming</td>
<td>Species richness:
Average number of species caught in each lake</td>
</tr>
</table>

<table>
<tr>
<td>the occurrence and abundance of fish populations in acidified Swedish lakes." Hydrobiologia 230(3): 201-212.</td>
<td>Scandinavia unclear on exact lakes included (and if there is overlap with other studies).</td>
<td>Lowest pH before liming mean 5 (range 3.8-6.1), after liming pH increased and mean was 5.8</td>
<td>during test fishing (taking the effects of temperature and number of nets into account)
<table>
<tr><td>Before liming</td><td>After liming</td></tr>
<tr><td>3.2</td><td>3.8</td></tr>
</table>
Effect size (log ratio): 0.17
Errors in the estimates not given but the difference is stated to be significant to the level p<0.05

Abundance:
Catch in numbers per unit effort of dominant species
Log ratio effect size is also presented (the errors in the mean were not given but the significance of the before after difference is:
<table>
<tr><td></td><td>Before</td><td>After</td><td>Effect size</td><td>Difference?</td></tr>
<tr><td>All species</td><td>13.6</td><td>24.2</td><td>0.58</td><td>p<0.001</td></tr>
<tr><td>Perch</td><td>9</td><td>15.9</td><td>0.57</td><td>p<0.001</td></tr>
<tr><td>Roach</td><td>5.3</td><td>10.2</td><td>0.65</td><td>p<0.01</td></tr>
<tr><td>Pike</td><td>0.19</td><td>0.23</td><td>0.19</td><td>p=0.46</td></tr>
<tr><td>Cisco</td><td>0.8</td><td>2.2</td><td>1.01</td><td>p = 0.07</td></tr>
<tr><td>Whitefish</td><td>0.69</td><td>0.81</td><td>0.16</td><td>p=0.78</td></tr>
</table>
</td>
</tr>
<tr>
<td>Eriksson, M. O. G. and B. Tengelin (1987). "Short-term effects of liming on perch Perca fluviatilis populations in acidified lakes in south-west Sweden." Hydrobiologia 146(2): 187-191.</td>
<td>BACI,
8 limed, 6 control lakes

Data from year before liming (1983) and one year after liming (1985)</td>
<td>Limed by direct liming to lakes in Summer/Autumn 1983 with 17-55g.m^{-3}

pH in limed lakes before (4.6-5.7) after 6.2-7.1) controls: before 4.5-6.3, after 4.5-6.2</td>
<td>Abundance:
Catch per unit effort of Perch
<table>
<tr><td></td><td>Before liming (1983)</td><td>After liming (1985)</td></tr>
<tr><td>Limed lakes</td><td>16 (SD 10)</td><td>122 (SD 270)</td></tr>
<tr><td>Control lakes</td><td>8 (SD 6)</td><td>9 (SD 10)</td></tr>
</table>
Effect size (log ratio): 1.01 (SE 0.54)</td>
</tr>
<tr>
<td>Gunn, J. M., et al. (1988). "Changes in the fish community</td>
<td>BA, 1 lake</td>
<td>Liming directly into lake with 6.8 x 10^4 kg of Ca(OH)2 and 10.2 x 10^4</td>
<td>Abundance:
Pelagic trap data, Number caught per 24hrs</td>
</tr>
</table>

<table>
<tr>
<td>of a limed lake near Sudbury, Ontario: effects of chemical neutralization or reduced atmospheric deposition of acids?" Water, Air, & Soil Pollution 41(1): 113-136.</td>
<td>Data from 1 year before liming and one to 3 years after liming</td>
<td>kg of $CaCO_3$ 1975 -76

pH before liming yearly mean 5.6 – 5.8 after liming 6.3 – 6.7</td>
<td>
<table>
<tr><td>Species</td><td>Before liming 1975</td><td>After liming 1976</td><td>Effect size (log ratio)</td></tr>
<tr><td>Yellow Perch</td><td>99.79</td><td>21.77</td><td>-1.52</td></tr>
<tr><td>Brown Bullhead</td><td>3.5</td><td>1.33</td><td>-0.97</td></tr>
<tr><td>Iowa Darter</td><td>0.44</td><td>0.3</td><td>-0.38</td></tr>
<tr><td>Central Mudminnow</td><td>0.44</td><td>0.07</td><td>-1.83</td></tr>
<tr><td>Brook Trout</td><td>0.15</td><td>0</td><td></td></tr>
</table>

Small mesh gillnets, number caught per 5 gillnet sets overnight
<table>
<tr><td>Species</td><td>Before liming 1975</td><td>After liming Average (1980, 84, 87)</td><td>Effect size (log ratio)</td></tr>
<tr><td>Lake trout</td><td>1</td><td>29.3</td><td>3.38</td></tr>
<tr><td>Lake Chub</td><td>5</td><td>28.7</td><td>1.75</td></tr>
<tr><td>Yellow Perch</td><td>0</td><td>70.5</td><td></td></tr>
<tr><td>Northern Pike</td><td>0</td><td>1</td><td></td></tr>
<tr><td>Brown Bullhead</td><td>0</td><td>1</td><td></td></tr>
<tr><td>Small-mouth Bass</td><td>0</td><td>1</td><td></td></tr>
</table>
</td>
</tr>
<tr>
<td>Holmgren, K. (2001). "Biomass-size distribution of the aquatic</td>
<td>CI benthic fish, 6 limed, 2 acid</td>
<td>Limed according to the Swedish national liming program protocol,</td>
<td>Abundance, biomass of benthic fish (g/m^2)
<table>
<tr><td>Limed lakes</td><td>Control lakes</td></tr>
</table>
</td>
</tr>
</table>

<table>
<tr>
<td>community in limed, circumneutral and acidified reference lakes." Water Air and Soil Pollution 130(1-4): 1751-1756.</td>
<td></td>
<td>details for lakes not given.
pH limed sites mean 7 (0.2) control 5.9 (0.0)</td>
<td>
<table>
<tr><td>15.1</td><td>21.0</td></tr>
</table>
Effect size (log ratio):-0.33
</td>
</tr>
<tr>
<td>Iivonen, P., et al. (1995). "Chemical, biological and socio-economic approaches to the liming of Lake Alinenjärvi in southern Finland " Water, Air, & Soil Pollution 85(2): 937-942.</td>
<td>BA, 1 lake,

Data from 4 yrs before liming (1986,89,90 and 91) and 3 yrs after (1992, 93 and 94).</td>
<td>Limed by limestone powder directly to lake

pH before 5.8-6.2, after 6.5-7.3</td>
<td>
Abundance
Mean catch per gill net series (kg)
<table>
<tr><td>Species</td><td>Average before liming</td><td>Average after liming</td><td>Effect size (log ratio)</td></tr>
<tr><td>Ruffe</td><td>0.85 (SD 0.14)</td><td>0.38 (SD 0.21)</td><td>-0.81 (SE 0.23)</td></tr>
<tr><td>Pike</td><td>0.58 (SD 0.62)</td><td>0.34 (SD 0.30)</td><td>-0.53 (SD 0.68)</td></tr>
<tr><td>Whitefish</td><td>2.2 (SD 1.8)</td><td>0.68 (SD 1.13)</td><td>-1.17 (SD 0.99)</td></tr>
<tr><td>Roach</td><td>5.9 (SD 4.4)</td><td>3.5 (SD 2.3)</td><td>-0.51 (0.47)</td></tr>
<tr><td>perch</td><td>2.1 (SD 0.9)</td><td>6.4 (SD 3.5)</td><td>1.13 (0.53)</td></tr>
<tr><td>total</td><td>11.5 (SD 3.9)</td><td>11.3 (SD 4.2)</td><td>-0.02 (SD 0.21)</td></tr>
</table>
</td>
</tr>
<tr>
<td>Nyberg, P., M. Appelberg, et al. (1986). "Effects of liming on crayfish and fish in Sweden." Water, Air, & Soil Pollution 31(3): 669-687.</td>
<td>BA, 26 lakes (successfully limed lakes , details of the identity of the lakes not given)

Unclear exactly how many years before and after liming</td>
<td>Details of liming not given
pH before liming <5.5, after liming >5.5</td>
<td>
Species richness
<table>
<tr><td>Before liming</td><td>After liming</td></tr>
<tr><td>2.5</td><td>2.8</td></tr>
</table>
Effect size (log ratio): 0.11
Error is not given but the difference is stated as not be significantly significant.

Abundance:
Number of fish (all species) per gillnet
<table>
<tr><td>Before</td><td>After</td></tr>
<tr><td>11.9 (SD 1.6)</td><td>33.8 (SD 3.5)</td></tr>
</table>
Effect size (log ratio): 1.04 (SE 0.05)
</td>
</tr>
<tr>
<td>Popp, W., et al. (1996). "Fish-community response to protective</td>
<td>BA, 1 lake,</td>
<td>Limed with 4.6 tonnes calcium carbonate slurry</td>
<td>Abundance
Biomass estimates (kg)</td>
</tr>
</table>

<table>
<tr>
<td>liming in Thrush Lake Minnesota." Restoration Ecology 4(3): 313-323.</td>
<td>Data from one year before liming (1987) and three years after liming (1989,90 and 91)</td>
<td>pH increased after liming</td>
<td>
<table>
<tr><td></td><td>Before liming</td><td>After liming</td><td>Effect size (log ratio)</td></tr>
<tr><td>Pearl Dace</td><td>8.4</td><td>6.8 (SD 3.0)</td><td>-0.20 (SE 0.43)</td></tr>
<tr><td>Fathead minnow</td><td>6.5</td><td>72 (SD 62)</td><td>2.42 (SE 9.58)</td></tr>
<tr><td>Brook trout</td><td>67</td><td>207 (SD 8)</td><td>1.12 (SE 0.12)</td></tr>
</table>
</td>
</tr>
<tr>
<td>Saksgard, R. and T. Hesthagen (1995). "Differences in response to liming in a lake-dwelling fish community." Water, Air, & Soil Pollution 85(2): 973-978.</td>
<td>BA, 1 lake

Data from one year prior to liming (1983) and three years after liming (1991,92 and 93)

Three sites sampled each year</td>
<td>Details of liming methods not given
pH early 1970s 5.2 to 6.0, after liming pH 5.9- 7.4</td>
<td>Abundance (catch per unit effort)
<table>
<tr><td></td><td>Before liming</td><td>After liming</td><td>Effect size (log ratio)</td></tr>
<tr><td>Artic Char</td><td>3.7 (SD 6.5)</td><td>2.7 (SD 2.6)</td><td>-0.32 (SE 0.73)</td></tr>
<tr><td>Perch</td><td>50.7 (SD 1.4)</td><td>12.2 (SD 9.8)</td><td>-1.43 (SE 0.26)</td></tr>
<tr><td>Whitefish</td><td>2.9 (SD 1.9)</td><td>1.1 (SD 0.5)</td><td>-1.01 (0.35)</td></tr>
</table>
</td>
</tr>
</table>

C.2 Studies presenting statements on species richness or abundance

Study	Design	Results
Norberg, M., C. Bigler, et al. (2008). "Monitoring compared with paleolimnology: implications for the definition of reference condition in limed lakes in Sweden." Environmental monitoring and assessment 146(1-3): 295-308.	BA, 12 lakes	Statement that fish in 10/12 monitoring lakes recovered from acidification affect, one unknown, one still affected by acidification.
Nyberg, P. (1984). "Effects of liming on fisheries." Philosophical Transactions of the Royal Society of London, B 305(1124): 549-560.	BA, unclear number of lakes	States that in all lakes with sufficient pH increase reproduction successful. Also out of 20 (unspecified lakes) 16 increased abundance of fish after liming. Specific data only given for case studies.
Booth, G. M., J. G. Hamilton, et al. (1986). "Liming in Ontario: short-term biological and chemical changes." Water, Air, & Soil Pollution 31(3): 709-720.	BA, 2 lakes	Studies in Trout Lake have not detected any short-term changes in the fish community or in any individual populations which might be attributed to liming
Gordon, W. "Liming and Brook Trout Restoration in the AdirondacksExample of Liming Success: Restoration of Two Adirondack Brook Trout Populations Lost To Acidification." New York State Department Of Environmental Conservation.	BA, 1 lake	Increases in fish populations but also stocking and selected as case studies of success
Bradt, P. T. (1996). "Limestone to mitigate lake acidification: macrozoobenthos response in treated and reference lakes." Hydrobiologia 317(2): 115-126.	BA, 1 lake	Limestone application had few discernible effects the fish community (Arnold & Friday, 1989)
Appelberg, M. (1998). "Restructuring of Fish Assemblages in Swedish Lakes Following Amelioration of Acid Stress through Liming." Restoration Ecology 6(4): 343-352.	BA,	Large variability between lakes in changes in CPUE; generally increased with time but also in two limed lakes significantly decreased no precise data can be estracted
Angeler, D. G. and W. Goedkoop (2010). "Biological responses to liming in boreal lakes: an assessment using plankton, macroinvertebrate and fish communities." Journal of Applied Ecology 47(2): 478-486.	CI, 11 limed, 4 acid	Results of statistical analysis presented but not numerical differences; lower biomass of fish in limed than acid or neutral lakes, no difference in species richness.

C.3 North American Stocking studies

Study	Results and Methods
Woods lake, Adirondacks, NY state, USA Gloss, S. P., et al. (1989)a "Survival, growth, reproduction, and diet of brook trout (Salvelinus fontinalis) stocked into lakes after liming to mitigate acidity." Canadian Journal of Fisheries and Aquatic Sciences 46(2): 277-286. And: Schofield, C. L. and C. Keleher (1996). "Comparison of brook trout reproductive success and recruitment in an acidic Adirondack lake following whole lake liming and watershed liming." Biogeochemistry 32(3): 323-337.	**Findings:** To begin with only reproduced in artificial redds but after second catchment liming stocked fish reproduced and ratio of natural to stocked trout caught increased. **Control?** No stocking prior to liming or control sites **Replication:** 1 lake **Liming:** $CaCO_3$ was added to the water column, later the catchment to two tributaries was limed pH prior to liming 4.5-5.2, after first liming pH 4.8 – 7.9, after catchment liming pH seasonal fluctuation in pH were reduced along with stream acidity
ELS lakes, Adirondacks, NY state, USA Gloss, S. P., et al. (1989)b "Liming and fisheries management guidelines for acidified lakes in the Adirondack region."	**Findings:** In 5/7 lakes stocked fish survived, percentage survival not shown just relative difference in survival between two different strains. (Also in 3 limed lakes water became anoxic so fish did not survive). No data given on if there was natural reproduction after liming **Control?** No test stocking prior to liming or control sites **Replication:** 7 lakes **Liming:** Dose rate varied from 43 to 183 g/m^3, ANC lake means went from -35.3 – 3.6 to 11-148.
Whitepipe lake Ontario Canada Carbone, J., W. Keller, et al. (1998). "Effects of changes in acidity on aquatic insects in rocky littoral habitats of lakes near Sudbury, Ontario." Restoration Ecology 6(4): 376-389.	**Findings:** Unsuccessful stocking of aurora trout (rare colour variant of Salvelinus fontinalis brook trout) in Whirligig prior to liming, successful after liming in 1990, and reproduction population established. Data on other fish in lake not mentioned **Control?** Unsuccessful stocking prior to liming **Replication:** 1 lake **Liming:** Limed with powdered limestone
Bowland lake Ontario Canada Gunn, J. M., J. G. Hamilton, et al. (1990). "Survival, Growth, and Reproduction of Lake Trout (Salvelinus namaycush) and Yellow Perch (Perca flavescens) After Neutralization of an Acidic Lake near Sudbury, Ontario." Canadian Journal of Fisheries and Aquatic Sciences 47, no(2): 446.	**Findings:** Pre-liming attempt to stock trout referenced as unsuccessful. After liming brook trout stocked and observed to reproduce. (Survival experiment also showed that prior to liming trout showed low survival which increased after liming). **Control?** Pre-liming stocking recorded as unsuccessful **Replication:** 1 lake **Liming:** Prior to liming lake acidic (pH 4.8-5.2) after liming 6.7, limed with 84t dry powdered limestone

Laural bed, USA Downey, D. M. and T. M. Hampton (2005). "Effects of Protective Limestone Treatment on Water Chemistry and Fisheries Management in Laurel Bed Lake, Virginia." Lake and Reservoir Management 21(4): 411-422.	**Finding:** Reservoir to control sream flow, drained before liming to repair dam and Rock bass (*Ambloplites rupestris*) removed as population was "over populated and stunted" and lake treated with rotenone. Lake acid due to construction on acid bog as well as acid precipitation. Previous efforts to restore lake had taken place. "Late 1980s, the fishery was entirely based on annual stockings of adult (>25 cm) hatchery raised trout with little post summer survival" After liming, some stocked brook trout survived but by 2002 when pH still greater than six, >20000 fish stocked but only one re-caught. No self-sustaining population Small mouth bass also stocked and population successfully established; "Some amount of natural reproduction was evident in 2002 and 2003, when smallmouth bass <100-mm TL were collected without supplemental stocking." **Control?** Previous efforts to stock lake had taken place **Replication:** 1 lake **Liming:** After liming pH remained greater than 6pH

C.4 Details of the European stocking studies.

Species	Study	Results and Methods
Brown trout	Loch fleet, UK Turnpenny, et al. (1995). "The brown trout population at Loch Fleet eight years after liming." Chemistry and ecology 9(3-4): 179-191.	**Findings:** Fish present in loch in 1950s, attempts to start stocking in 1960s but no fish present in 1975. Survival tests before liming suggest water not of high enough quality; high juvenile mortality. Brown trout stocked after liming and started to reproduce and population grew, to 4 fold the number of stocked fish (implies but not explicitly stated that stocking only occurred in first two years after liming and since then increases in population all natural recruitment). **Control?** Stocking attempted before liming and unsuccessful **Replication:** 1 lake **Liming:** Catchment liming, total of 350t limestone applied. pre treatment - 4.4, Post treatment approx 6-7
Brown trout	Hovvatn, Barlaup, et al. (1994). "Stocking of brown trout (Salmo trutta L.) cohorts after liming - effects on survival and growth during five years of reacidification." Water, Air, & Soil Pollution 72(1): 317-330.	**Findings:** No fish before liming, stocking after liming and fish survived Liming and stocking started in 1981 but no natural recruitment occurred until 1989 after repeated liming (1987, 1989) and stocking (1981-1985, 1987, 1989). Despite redds being observed (most embryos in redds found were dead). Only significant natural recruitment in 1993/4 after additions of limestone onto redds, still unclear if it could maintain a self-sustaining population. **Control?** No stocking prior to liming or control sites, difference in level of reproduction with level of liming **Replication:** 1 lake **Liming:** Limed directly into lake and later onto redds

Brown trout (and rainbow trout)	Svensson, et al. (1995) Liming strategies and effects: the Lake Gardsjon case study. In: Limin og acifided Surface Waters eds L. Henrickson and Y. W. Brodin (Springer-Verlag, Berlin Heidelberg)	**Findings:** Stocked fish survived but there was no reproduction. No fish were present prior to liming and brown trout were not present in an inventory of the fish in 1949, suggesting they may never have reproduced in the lake. A non-native species, rainbow trout, *Oncorhynchus mykiss,* was also introduced **Control?** No stocking prior to liming **Replication:** 1 lake **Liming:** liming increasing pH to about 7.6 and then remained relatively stable above 6
Brown tout (and brook trout)	Traaen et al. (1997). "Whole-catchment liming at Tjnnstrond, Norway: an 11-year record." Water, Air, and Soil Pollution 94(1/2): 163-180.	**Findings:** Stocked fish survived and a few fish were caught which "appear not to have originated from any known stocking" from their age classifications, however, "this may be due to incorrect age classification" and it is not clear whether any reproduction took place. The paper suggests there does not appear to be a self sustaining population of either species. However, the authors state that lakes 'historically' contained brown trout populations but these were 'dependent on regular stocking because of lack of spawning areas" so the lake does not naturally contain a stable brown trout population. **Control?** No stocking prior to liming **Replication:** 1 lake **Liming:** Whole catchment was limed.
Perch	Hesthagen, et al. (2001). "Low Success Rate in Re-Establishing European Perch in Some Highly Acidified Lakes in Southernmost Norway." Water, Air, & Soil Pollution 130(1-4): 1361-1366.	**Findings:** in one out of three acid lakes introduced perch survived and reproduced (CPUE=6.7 juveniles in 1999), in the single limed lake perch survived and reproduced to greater extent (juvenile CPUE= 52.9 in 1999) (stocking rate 117-177per ha, unclear if difference between acid and limed lakes). **Control?** Stocking occurred in both limed and acid lakes **Replication:** 1 limed, 3 control **Liming:** limed with 800kg powdered limestone
Roach and Bream	Lake Gyslättasjön Appelberg (1995). "Liming strategies and effects: The Lake Gyslattasjon case study." Liming of acidified surface waters: A Swedish synthesis: 353-361.	**Findings:** Fish introduced, survived and reproduced, populations grew. Lake limed by both catchment liming and direct liming into lake at one to four yearly intervals. With first liming, pH increased from 4.8 to over 6, decreased over first few years then increased to around 6 again and remained relatively stable. **Control?** No attempt at stocking prior to liming mentioned and no test of fish survival. **Replication:** 1 lake **Liming:** Lime applied directly to lake at irregular intervals (in 1985, 87, 88 and 91) pH before liming 4.8-6, after 5.6-7.2
Char	Lake Vastra Skalsjon , Nyberg, P. (1995). "Liming strategies and effects: The Lake Vastra Skalsjon case study." Liming of acidified surface waters: A Swedish synthesis: 328-338.	**Findings:** Char reintroduction successful – population established, increased in size and natural reproduction occurred (although not straight away). Other fish species present before liming **Control?** **Replication:** 1 lake **Liming:**

	Stora Holmevatten, Hasselrot, et al. (1984). "Ecosystem shifts and reintroduction of Arctic char (Salvelinus salvelinus (L.)) after liming of a strongly acidified lake in southwestern Sweden." Institute of Freshwater Research Drottningholm Report 61: 78-92.	**Findings:** Char survived and reproduced. **Control?** No attempt at stocking prior to liming mentioned and no test of fish survival **Replication:** 1 lake **Liming:** Limed autumn 1981 with 1225 tons and 1989 with 657 tons, since limed continuously via lime dosers on affluent pH about 4.5 to 7-8

C.5 Studies not included within the analysis

Article	Reason for exclusion
Rask, M., M. Jarvinen, et al. (1996). "Limnological responses to the collapse of the perch population in a small lake." Annales Zoologici Fennici 33(3-4): 517-524.	perch population crashed in control section of lake (divided by plastic curtain) possibly due to toxic mixing zones
Appelberg, M. and T. Svenson (2001). "Long-term ecological effects of liming - The ISELAW programme." Water Air and Soil Pollution 130(1-4): 1745-1750.	Data within Appelberg 1998
Barlaup, B. T., A. Hindar, et al. (1998). "Incomplete mixing of limed water and acidic runoff restricts recruitment of lake spawning brown trout in Hovvatn, southern Norway." Environmental Biology of Fishes 53(1): 47-63.	Data within Barlaup et al 1994
Barlaup, B. T., A. Atland, et al. (1989). "Improved growth in stunted brown trout (Salmo trutta L.) after reliming of lake Hovvatn, southern Norway." Water, Air, & Soil Pollution 47(1): 139-151.	Data within Barlaup et al 1994
Brown, D. J. A., G. D. Howells, et al. (1988). "Loch Fleet - a research watershed liming project." Water, Air, and Soil Pollution 41(1-4): 25-41.	Data within Turnpenny 1995
Casselman, J. M. and J. M. Gunn (1992). "Dynamics in Year-Class Strength, Growth, and Calcified-Structure Size of Native Lake Trout (Salvelinus namaycush) Exposed to Moderate Acidification and Whole-Lake Neutralization." Canadian Journal of Fisheries and Aquatic Sciences CJFSDX 49(1): 102-113.	Data within Gunn et al 1990
Howells, G., T. R. K. Dalziel, et al. (1992). "Loch Fleet: Liming to Restore a Brown Trout Fishery." Environmental Pollution ENPOEK 78(1): 131-139.	Data within Turnpenny 1995
Hultberg, H. and P. Grennfelt (1986). "Gårdsjön Project: lake acidification, chemistry in catchment runoff, lake liming and microcatchment manipulations." Water, Air, & Soil Pollution 30(1): 31-46.	Data within Svensson etal 1995
Porcella, D. B. (1988). "Update on the Lake Acidification Mitigation Project (LAMP)." Water, Air, and Soil Pollution WAPLAC 41(1-4): 43-51.	Data within Gloss etal 1989 and Schofield et al 1991

Raddum, G. G., P. Brettum, et al. (1986). "Liming the acid lake Hovvatn, Norway: A whole-ecosystem study." Water, Air, & Soil Pollution 31(3): 721-763.	Data within Barlaup et al 1994
Rosseland, B. O. and A. Hindar (1988). "Liming of lakes, rivers and catchments in Norway." Water, Air, & Soil Pollution 41(1): 165-188.	Data within Barlaup et al 1994 and Traaen et al 1997
Schofield, C. L., C. Keleher, et al. (1991). "Population dynamics of brook trout (Salvelinus fontinalis) during maintenance liming of an acidic lake." Water, Air, & Soil Pollution 59(1-2): 41-53.	Data within Gloss et al 1989
Schofield, C. L. and C. Keleher (1996). "Comparison of brook trout reproductive success and recruitment in an acidic Adirondack lake following whole lake liming and watershed liming." Biogeochemistry 32(3): 323-337.	Data within Schofield et al 1991
Schofield, C. L., S. P. Gloss, et al. (1989). "Production and growth efficiency of brook trout (Salvelinus fontinalis) in two Adirondack mountain (New York) lakes following liming." Canadian Journal of Fisheries and Aquatic Sciences 46(3): 333-341.	Data within Gloss et al 1989
Turnpenny, A. W. H. (1992). Fishery Restoration After Liming. Restoring Acid Waters: Loch Fleet 1984-1990. G. Howells and T. R. K. Dalziel: 259.	Data within Turnpenny 1995

Appendix D. Summary of articles reporting data on zooplankton

D.1 Studies within the zooplankton meta-analysis.

<table>
<tr><th>Study</th><th>Location</th><th>Study Design</th><th>pH change</th><th>Results</th></tr>
<tr><td>Blomqvist, P., R. T. Bell, et al. (1995). "Plankton and water chemistry in lake Njupfatet before and after liming." Canadian Journal of Fisheries and Aquatic Sciences 52(3): 551-565.</td><td>Njupfatet, Sweden</td><td>BA, 1 lake, enclosure experiments also took place within the lake with nutrient additions and spp manipulations</td><td>Lake and outflows (into lake) of 2 small bogs limed with 20tonnes finely ground limestone. pH 5.64 to 7.17 mean (range 5.3-6.0 to 6.6-7.6)</td><td>Biomass and Diversity
<table><tr><td></td><td>Before liming (1989)</td><td>After liming (1990)</td></tr><tr><td>Total biomass (µg/Lw.w.)</td><td>86 (13)</td><td>109 (34)</td></tr><tr><td>Shannon index H' (biomass)</td><td>1.36 (0.43)</td><td>1.34 (0.43)</td></tr></table>Effect size (log ratio) biomass 0.24 (SE 0.11); diversity -0.01 (0.12)</td></tr>
<tr><td>Ekstrom, C. and E. Hornstrom (1995). "Development of zooplankton in relation to lime treatment in two acidified lakes." Water Air and Soil Pollution 85(2): 925-930.</td><td>Ömmern Sweden</td><td>BA, 1 lake, Ommern (second lake mentioned but no before data given).</td><td>Limed autumn 1981 with 1225 tons and 1989 with 657 tons, since limed continuously via lime dosers on affluents
pH 5.3 to 6.5-7</td><td>Average number of zooplankton taxa
<table><tr><td>Pre-liming (1974-1981)</td><td>During liming (1982-1992)</td></tr><tr><td>15.2 (2.5)</td><td>16.9 (2.6)</td></tr></table>Effect size (log ratio) 0.11 (SE 0.05)</td></tr>
<tr><td>Elser, M. M., J. J. Elser, et al. (1986). "Paul and Peter lakes: A liming experiment revisited." American Midland Naturalist 116(2): 282-295.</td><td>PeterPaul USA</td><td>CI, lake of two joined basins split in two and one side limed, liming</td><td>pH pre-liming 5.9, post liming treatment 7.3-6.7, control 6.2-6.7</td><td>Zooplankton abundance
<table><tr><td>Peter – limed part</td><td>Paul – control part</td></tr><tr><td>157 (SD 161)</td><td>348 (111)</td></tr></table>Effect size -0.86 (0.83)
zooplankton biomass from 8 years after last</td></tr>
<tr><td>Eriksson, F., E. Hornstrom, et al. (1983). "Ecological Effects of Lime Treatment of Acidified Lakes and Rivers in Sweden." Hydrobiologia 101(1): 145-164.</td><td>Goup 1: Blanksjon, Iglafallssjon and Vibollsjon , Sweden

Group 2: 7 lakes in the</td><td>BA 3 groups of (3, 6 and 7 neighbouring lakes), 2 other groups of lakes mentioned in paper but data not presented</td><td>Group 1: Limed 1978, 1981, 1983 pH before 4.7-5.2, after 5.5-7.1

Groups 2: limed with lime slag</td><td>Group 1:
Average number of planktonic crustaceans May – October (individuals /L)
<table><tr><td></td><td>Blanksjon</td><td>Iglaffassjon</td><td>Vibollsjon</td></tr><tr><td>Pre-liming 1977</td><td>4.3</td><td>2.9</td><td>4.1</td></tr><tr><td>Post liming 1978-1981</td><td>20.7</td><td>14.9</td><td>14.3</td></tr></table>Effect size (log ratio) 1.49 (SE 0.22)
Group 2:</td></tr>
</table>

<table>
<tr>
<td></td>
<td>County of Bohuslan

Group 3: 6 lakes in the County of Varmland</td>
<td></td>
<td>($CaMgSiO_4$)(amount and timing unclear) pH before 5.0-5.2 (avg 5.1), after 5.5 – 8.2 (avg 6.5)

Group 3: Limed with fine crushed limestone
Before pH 5.5-5.9 (avg 5.5), after 6.9-7.2 (mean 7.0)</td>
<td>
<table>
<tr><td></td><td>Before</td><td>After</td></tr>
<tr><td>Species richness</td><td>15</td><td>23</td></tr>
<tr><td>Abundance</td><td>9.7</td><td>12.3</td></tr>
</table>
Effect size (log ratio): richness: 0.43, abundance 0.34

Group 3:
<table>
<tr><td></td><td>Before</td><td>After</td></tr>
<tr><td>Species richness</td><td>16</td><td>19</td></tr>
<tr><td>Abundance</td><td>16.9</td><td>23.2</td></tr>
</table>
Effect size (log ratio) richness: 0.17, abundance: 0.32
</td>
</tr>
<tr>
<td>Hasselrot, B., I. Andersson, et al. (1984). "Ecosystem shifts and reintroduction of Arctic char (Salvelinus salvelinus (L.)) after liming of a strongly acidified lake in southwestern Sweden." Institute of Freshwater Research Drottningholm Report 61: 78-92.</td>
<td>Stora Holmevatten Sweden</td>
<td>BA, 1 lake, charr stocked as well</td>
<td>Limed 205 tons ground limestone 1979 to lake, lakeshore and catchment area. pH about 4.5 to 7-8</td>
<td>Abundance and Species richness
<table>
<tr><td></td><td>Pre liming (1979)</td><td>Post-liming (1980-1983)</td></tr>
<tr><td>Number of species</td><td>2</td><td>10.8 (4.8)</td></tr>
<tr><td>Biomass (wet weight g/m^3)</td><td>0.06</td><td>0.24 (0.26)</td></tr>
</table>
Effect size 1.37 (4.61)</td>
</tr>
<tr>
<td>Hesthagen, T., B. r. Walseng, et al. (2007). "Effects of Liming on the Aquatic Fauna in a Norwegian Watershed: Why Do Crustaceans and Fish Respond Differently." Water, air & soil pollution 7(1-3): 339-345.</td>
<td>Lakes in the Enningdal watershed (largest Lake Søndre Boksjø), Norway</td>
<td>CI 15 limed lakes, 6 acid control lakes</td>
<td>Liming details unclear: “several lakes limed on an annual basis since 1980s”
pH limed 6.62 +/- 0.35, control 5.0±0.14</td>
<td>Number of crustacean species
<table>
<tr><td>Limed (SD)</td><td>Control</td></tr>
<tr><td>35.8 (4.5)</td><td>23.2 (2.0)</td></tr>
</table>
Effect size (log ratio): 0.43 (SE 0.08)</td>
</tr>
<tr>
<td>Holmgren, K. (2001). "Biomass-size</td>
<td>Swedish lakes from</td>
<td>CI
6 limed, 2 acid</td>
<td>Avg pH acid 5.9 (0.0), limed 7.0 (0.2)</td>
<td>Zooplankton biomass (mm^3/m^3)</td>
</tr>
</table>

<table>
<tr>
<td>distribution of the aquatic community in limed, circumneutral and acidified reference lakes." Water Air and Soil Pollution 130(1-4): 1751-1756.</td>
<td>the main liming program (ISELAW program) Gyltigesjon, Stora Harsjon, Stensjon, Lien, Vastra Skalsjon, Kallsjon (all included in Persson 2008)</td>
<td></td>
<td></td>
<td>
<table>
<tr><td>Limed lakes</td><td>Acid lakes</td></tr>
<tr><td>972</td><td>715</td></tr>
</table>
Effect size (log ratio): 0.31
Note: this effect size covers a subsample of the study above but is the opposite direction.
</td>
</tr>
<tr>
<td>Jarvinen, M., K. Kuoppamaki, et al. (1995). "Responses of phyto- and zooplankton to liming in a small acidified humic lake." Water, Air, & Soil Pollution 85(2): 943-948.</td>
<td>Iso Valkjärvi, Finland</td>
<td>CI experiment, lake divided into two by plastic curtain and one side limed</td>
<td>Limed with finely ground limestone directly into lake (May 1991) dose not stated
Before 5-5.5 after 6.5-7</td>
<td>Biomass (µg C/L) of zooplankton May –Sept each year
<table>
<tr><td>Year</td><td>Limed (SD)</td><td>Control (SD)</td></tr>
<tr><td>1991</td><td>86 (92)</td><td>133 (134)</td></tr>
<tr><td>1992</td><td>82 (54)</td><td>62 (54)</td></tr>
<tr><td>1993</td><td>82 (51)</td><td>66 (51)</td></tr>
</table>
Effect size (log ratio): 0.02 (SE 0.23)
(the mean yearly log ratio)
</td>
</tr>
<tr>
<td>Nyberg, P. (1998). "Biotic Effects in Planktonic Crustacean Communities in Acifified Swedish Forest Lakes after Liming." Water, Air, & Soil Pollution 101(1-4): 257-288.</td>
<td>Various Sweden Trehörningen, Längsjön, Mörtsjön, V. Skälsjön, Ö. Skälsjön, St. Sirsjön, L. Sirsjön, Blanksjön, Iglafallssjön, Vibollsjön</td>
<td>BA, 10 lakes, In 4 different groups (one group Blanksjon, Iglafallssjon and Vibollsjon included in study above but not included in abundance data)</td>
<td>Limed directly to lake, along shore, in tributaries and by upstream lakes
Pre means (4.7 to 5.8) Post (5.2 to 6.6) all had increased</td>
<td>Number of species
<table>
<tr><td>Lake</td><td>T</td><td>L</td><td>M</td><td>V.S</td><td>O.S</td><td>S.S</td><td>L.S</td><td>B</td><td>I</td><td>V</td></tr>
<tr><td>preliming</td><td>5</td><td>6</td><td>7</td><td>5</td><td>9</td><td>4</td><td>6</td><td>4</td><td>4</td><td>4</td></tr>
<tr><td>postliming</td><td>10</td><td>10</td><td>10</td><td>7</td><td>10</td><td>13</td><td>11</td><td>11</td><td>10</td><td>9</td></tr>
</table>
Effect size (log ratio) 0.65 (SE 0.34)

Abundance planktonic crustaceans (ind/l)
<table>
<tr><td>Lake</td><td>T</td><td>L</td><td>M</td><td>V.S</td><td>O.S</td><td>S.S</td><td>L.S</td></tr>
<tr><td>Pre-liming</td><td>21.4</td><td>30.5</td><td>81.4</td><td>14.3</td><td>13.3</td><td>35.7</td><td>21.7</td></tr>
<tr><td>Post-liming</td><td>24.9</td><td>20.2</td><td>71.8</td><td>8.7</td><td>14.4</td><td>14.2</td><td>14.1</td></tr>
</table>
Effect size (log ratio): -0.39 (SE 0.38)
</td>
</tr>
<tr>
<td>Persson, G. (2008). "Zooplankton response to</td>
<td>various Sweden</td>
<td>CI, 14 limed lakes from the</td>
<td>Limed according to the national</td>
<td>Mean number of taxa in summer net samples (1990-1992)
<table>
<tr><td>Limed lakes</td><td>Acid lakes</td></tr>
</table>
</td>
</tr>
</table>

<table>
<tr>
<td>long-term liming: Comparison of 15 limed and 15 reference lakes in Sweden." Limnologica 38(1): 1-13.</td>
<td>Källsjön, N. Samamannasjon, Bosjon, Tryssjon, Vastra Skalsjon, Lien, Stensjon, Ejgdesjon, Langsjon, Stora Harsjon, Stengardshulasjon, Gyslattasjon, Gyltigesjon, Nassjon, Blanksjon</td>
<td>ISELAW long term monitoring, 7 acid Controls</td>
<td>recommendations Average pH acid 5.23, limed 6.70</td>
<td>
<table>
<tr><td>22.9 (1.2)</td><td>11.6 (3.7)</td></tr>
</table>
Effect size (log ratio): 0.68 (SE 0.08)

Density of Rotatoria, Cladocera and Copepoda (ind/L)
<table>
<tr><td>Limed lakes</td><td>Acid lakes</td></tr>
<tr><td>138</td><td>183</td></tr>
</table>
Effect size (log ratio): -0.28
</td>
</tr>
<tr>
<td>Scheider, W. and P. J. Dillon (1976). "Neutralization and fertilization of acidified lakes near Sudbury, Ontario." Water Pol 1 . Research Canada.</td>
<td>Middle, Lohi, USA (Clearwater and Hannah as controls)</td>
<td>BACI, 2 control and 2 treatment lakes year before treatment and year after.</td>
<td>Limed in 1973 by fine powdered calcium carbonate slurry over lake surface
pH control 4.3-4.5, treatment before 4.4-4.5, after, 6.2,7.0</td>
<td>Zooplankton standing crop (number/l)
<table>
<tr><td></td><td>Middle - limed</td><td>Lohi - limed</td><td>Hannah - control</td><td>Clearwater control</td></tr>
<tr><td>Before 1973</td><td>18.6</td><td>65.4</td><td>1.73</td><td>9.51</td></tr>
<tr><td>After 1974</td><td>0.66</td><td>2.07</td><td>1.50</td><td>23.5</td></tr>
</table>
Effect size (log ratio): -3.89
</td>
</tr>
<tr>
<td>Stenson, J. A. E. and J. E. Svensson (1994). "Manipulations of planktivore fauna and development of crustacean zooplankton after restoration of the acidified Lake Gaardsjoen." Archiv fur Hydrobiologie. Stuttgart 131(1): 1-23.</td>
<td>Gårdsjön, Sweden</td>
<td>BACI, 1 limed, 1 control (control basin very similar to limed lake and in same drainage area)</td>
<td>Limed as lime-water mix directly to lake in 1982 (100 tonnes finely ground limestone)
Second application in 1985
pH limed 4.67 to 7.35, control 5.41 to 5.31</td>
<td>Number of identified cladoceran and rotifer species (May to September each year)
<table>
<tr><td></td><td>Garsjon</td><td>Control</td></tr>
<tr><td>Before liming (1979 – 1981)</td><td>18.2 (0.7)</td><td>14.5 (0.6)</td></tr>
<tr><td>After liming (1982-1991</td><td>28.7 (4.8)</td><td>17.7 (3.5)</td></tr>
</table>
Effect size

Bio-volume of rotifers and cladoceran (mm^3/L)
<table>
<tr><td></td><td>Garsjon</td><td>Norra Hastevatten</td></tr>
<tr><td>Before liming (1979 – 1981)</td><td>0.24</td><td>0.18</td></tr>
<tr><td>After liming (1982-1991</td><td>0.63</td><td>0.34</td></tr>
</table>
Effect size (log ratio) 0.36
</td>
</tr>
<tr>
<td>Wright, D., M. Danks, et al. (1996). "Impact of a</td>
<td>Thrush lake USA</td>
<td>BA, 1 lake</td>
<td>Liming took place as a preventative</td>
<td>Zooplankton abundance (10^3 ind/m^3)
<table>
<tr><td>Pre liming (1986-1988)</td><td>Post liming (1988-1990)</td></tr>
</table>
</td>
</tr>
</table>

<table>
<tr>
<td>protective limestone treatment on the water chemistry and zooplankton community of Thrush Lake, Minnesota." Restoration Ecology 4(3): 293-306.</td>
<td></td>
<td></td>
<td>measure, lake not acid before liming. Liming by spraying limestone slurry on surface of lake pH before 5.8-6.9 after 9 then 6.5 -7.5</td>
<td>
<table>
<tr><td>68.8 (45.6)</td><td>65.6 (31.1)</td></tr>
</table>
Effect size -0.05 (SE 0.21)

Also change in composition but diversity not given
</td>
</tr>
<tr>
<td>Yan, N. D., W. Keller, et al. (1996). "Recovery of crustacean zooplankton communities from acid and metal contamination: Comparing manipulated and reference lakes." Canadian journal of fisheries and aquatic sciences/Journal canadien des sciences halieutiques et aquatiques. Ottawa ON 53(06): 1301-1327.</td>
<td>Nelson Lake USA

Hannah and Middle lakes, USA</td>
<td>BA, Data on 3 lakes but divided into two sets: Nelson and Hannah

Nelson lake data from before to a long time after liming,

Hannah
BA, 2 lakes (1 lake, Hannah downstream of other, Middle),</td>
<td>Nelson limed in 1976
pH preliming 4.3-4.4, post 6.5 to 7.2

Hannah limed in 1975, Middle in 1974
pH preliming 5.5-5.8, post 6.1 to 6.5</td>
<td>
Nelson:
Abundance (animals/l)
<table>
<tr><td>Before liming (1973-1975)</td><td>After liming (1976, 1985-86, 1990-91)</td></tr>
<tr><td>23.5 (11.4)</td><td>23.8 (22.5)</td></tr>
</table>
Effect size (log ratio): 0.01 (2.3)

Species richness
<table>
<tr><td>Before liming (1973-1975) (SD)</td><td>After liming (1976, 1985-86, 1990-91)</td></tr>
<tr><td>5.0 (1.2)</td><td>8.7 (0.8)</td></tr>
</table>
Effect size (log ratio): 0.56 (SE 0.26)
Directly after liming both decreased

Hannah:
Abundance (animals/l)
<table>
<tr><td></td><td>Before liming</td><td>After liming</td></tr>
<tr><td>Hannah</td><td>1.0 (0.3)</td><td>25.9 (14.5)</td></tr>
<tr><td>Middle</td><td>11.5</td><td>14.9 (12.2)</td></tr>
</table>
Effect size (log ratio): 1.8 (SE 2.3)

Species richness
<table>
<tr><td></td><td>Before liming (SD)</td><td>After liming</td></tr>
<tr><td>Hannah</td><td>2.6</td><td>3.3</td></tr>
<tr><td>Middle</td><td>2.6</td><td>3.3</td></tr>
</table>
Effect size (log ratio): 0.23 (SE 0.02)

Directly after liming both decreased
</td>
</tr>
</table>

D.2 Zooplankton studies not included within the meta-analysis, but that made statements on abundance or species richness

Article	Reason for exclusion from quantitative synthesis/ Results
Angeler, D. G. and W. Goedkoop (2010). "Biological responses to liming in boreal lakes: an assessment using plankton, macroinvertebrate and fish communities." Journal of Applied Ecology 47(2): 478-486.	CI 11 limed, 4 acid. No data given but results of statistics stated as showing no significant difference in biomass or richness
Appelberg, M. and T. Svenson (2001). "Long-term ecological effects of liming - The ISELAW programme." Water Air and Soil Pollution 130(1-4): 1745-1750.	No primary data presented, statement changes have been small
Appelberg, M., P. E. Lingdell, et al. (1995). "Integrated studies of the effects of liming acidified waters (ISELAW-programme)." Water Air and Soil Pollution 85(2): 883-888.	14 lakes in Swedish monitoring program but data not presented. Statement of increase in zooplankton taxa with liming.
Appelberg, M. (1995). "Liming strategies and effects: The Lake Gyslattasjon case study." Liming of acidified surface waters: A Swedish synthesis: 353-361.	BA, 1 lake , Relative abundance of different species presented but otherwise no before data given. Statement of increase after liming.
Edberg, F., P. Andersson, et al. (2001). "Reacidification Effects on Water Chemistry and Plankton in a Limed Lake in Sweden." Water, Air, & Soil Pollution 130(1-4): 1763-1768.	BA, 1 lake statement of before 12-29 taxa, after liming gradually increased to 40-50 but precise yearly data not given.
Iivonen, P., T. Järvenpää, et al. (1995). "Chemical, biological and socio-economic approaches to the liming of Lake Alinenjärvi in southern Finland " Water, Air, & Soil Pollution 85(2): 937-942.	No quantitative data. Statement that: "The density of crustacean zooplankton seemed to increase after liming"
Norberg, M., C. Bigler, et al. (2008). "Monitoring compared with paleolimnology: implications for the definition of reference condition in limed lakes in Sweden." Environmental monitoring and assessment 146(1-3): 295-308.	BA, 8 limed lakes. No quantitative data - reported increase in zooplankton with liming in all 8 lakes and in 4 lakes acid sensitive species developed after liming
Sandoey, S. and J. P. Nilssen (1987). "Cyclopoid copepods in marginal habitats: Abiotic control of population densities in anthropogenic acidic lakes." Archiv fuer Hydrobiologie, Supplement 76(3): 236-255.	Data from limed and control lakes given for selected individual species, however, no data on overall change in species richness or abundance. In general species increased in limed lakes but stable in control
Schaffner, W. R. (1989). "Effects of neutralization and the addition of brook trout (Salvelinus fontinalis) on the limnetic zooplankton communities of two acidic lakes." Canadian Journal of Fisheries and Aquatic Sciences 46(2): 295-305.	BA, 2 lakes (1 lake limed and reacificed quickly). Statement that abundance decreased after liming, abundances of individual species given but not total abundance or species richness .

D.3 Zooplankton studies not included within the analysis (and reason)

Article	Reason for exclusion
Bengtsson, B., W. Dickson, et al. (1980). "Liming acid lakes in Sweden." Ambio 9(1): 34-36.	Data presenting in Nyberg 1984
Henrikson, L., H. G. Oscarson, et al. (1984). "Development of the crustacean zooplankton community after lime treatment of the fishless Lake Gaardsjoen, Sweden." DROTTNINGHOLM. no. 61: 104-114.	Data presented in Stenson and Svenson 1994
Henrikson, L. and H. G. Oscarson (1984). "Lime influence on macro-invertebrate zooplankton predators." DROTTNINGHOLM. no. 61: 93-103.	Data presented in Stenson and Svenson 1994
Milner, A. G. P. and R. J. Aston (1995). "Pre- and post-liming aquatic communities and trout diets." Chemistry and ecology. London. 9: 3-4.	Changes of combined benthic and planktonic organisms, no data for zooplankton on their own.
Nilssen, J. P. and S. B. Waervagen (2002). "Intensive fish predation: An obstacle to biological recovery following liming of acidified lakes?" Journal of Aquatic Ecosystem Stress and Recovery 9(2): 73-84.	Percentage abundance of cladocerans in limed and acidic lakes. No data on overall change in abundance or species richness
Nilssen, J. P. and S. B. Waervagen (2003). "Ecological distribution of pelagic copepods and species relationship to acidification, liming and natural recovery in a boreal area." Journal of	Differences in relative copepod abundance in limed and acid lakes, no data on overall change in abundance or species richness

Limnology 62(1): 97-114.	
Nyberg, P. (1995). "Liming strategies and effects: The Lake Vastra Skalsjon case study." Liming of acidified surface waters: A Swedish synthesis: 328-338.	No clear before data available
Nyberg, P. (1984). "Impact of Chaoborus predation on planktonic crustacean communities in some acidified and limed forest lakes in Sweden." Drottningholm. no. 61: 154-166.	Data presented in Eriksson et al 1983
Raddum, G. G., P. Brettum, et al. (1986). "Liming the acid lake Hovvatn, Norway: A whole-ecosystem study." Water, Air, & Soil Pollution 31(3): 721-763.	BACI, details given for some specific species but not enough data to calculate changes in total abundance or species richness
Rask, M., M. Jarvinen, et al. (1996). "Limnological responses to the collapse of the perch population in a small lake." Annales Zoologici Fennici 33(3-4): 517-524.	Data presented in Jarvinen et al 1995
Stenson, J. A. E. (1990). "Creating conditions for changes in prey community structure by Chaoborus spp. in a lake in Sweden." Hydrobiologia 198: 205-214.	Data presented in Stenson and Svenson 1994
Stross, R. G., J. C. Neess, et al. (1961). "Turnover time and production of planktonic crustacea in limed and reference portion of a bog lake." Ecology 42: 237-245.	Data presented in Elser et al 1986
Vrede, K. (1996). "Regulation of bacterioplankton production and biomass in an oligotrophic clearwater lake - The importance of the phytoplankton community." Journal of Plankton Research 18(6): 1009-1032.	Data presented in Blomqvist et al 1995
Walseng, B., G. Halvorsen, et al. (2001). "Littoral microcrustaceans (Cladocera and Copepoda) as indices of recovery of a limed water system." Hydrobiologia 450(1-3): 159-172.	No data on abundance/species richness, changes presented as ordinations.
Walseng, B. and L. R. Karlsen (2001). "Planktonic and littoral microcrustaceans as indices of recovery in limed lakes in se Norway." Water Air and Soil Pollution 131(1-4 Part 3): 1313-1318.	No data given on changes in abundance/ species richness just how they vary along an ordination access according to presence and absences of species
Weglenska, T., J. EjsmontKarabin, et al. (1997). "Biotic interactions of the zooplankton community of a shallow, humic lake." Hydrobiologia 342: 185-195.	No clear before and after liming data available for total species abundance or diversity

Appendix E Summary of articles reporting data on phytoplankton

E.1 Studies included within the meta-analysis

Study	Location	Study Design	Liming /pH change	Results
Alenaes, et al. (1991). "Liming and reacidification reactions of a forest lake ecosystem, Lake Lysevatten, in SW Sweden." Water, Air, & Soil Pollution 59(1-2): 55-77.	Lysevatten	BA, 1 lake Sampled 2 times pre liming (over 1 yr) and 16 times post liming (over 5 yrs; 1974-1979)	60t spread from boat (equivalent to 76t agro-limestone) in 1974, (retreated in 1986 with 98t agro-limestone (50% CaO) but data only reported from first liming, After repeated liming statement that phytoplankton biomass increased greatly pH before 4.4 to 5 after 5.8 to 7.5	Biomass (g/m^2) Before liming: 1.06 (SD 0.97) After liming (before re-acidification): 0.63 (SD 0.59) Effect size (log ratio): -0.52 (SD 0.48)
Anderson, et al. (1997). "An experimental and palaeoecological study of algal responses to lake acidification and liming in three central Swedish lakes." European Journal of Phycology 32(1): 35-48.	Njupfatet (see Blomqvist et al 1995 for abundance data)	BA, 1lake, but core data available for 2 additional lakes - changes in relative abundance of different diatoms Samples from 1 year pre liming and 1 year post. Three winter and 10 summer samples each year.	Direct application of calcite onto lake surface (16 tonnes in 1989) pH before liming 5.3 to 5.7, immediately after liming 6.6 to 7.6	Number of species present Before liming, (Nov 1988 to Oct1989): 39 After liming, (Nov 1989 to Oct 1990): 41 Effect size (log ratio): 0.05
Battarbee, et al. (1992). Other Aquatic Biology: Fora and Fauna. Restoring Acid Waters: Loch Fleet 1984-1990. G. Howells and T. R. K. Dalziel.	Loch Fleet	BA, 1 lake, Sampled 5 times pre liming (Sept 1985 to Jan 1986) and 24 times post (March 1986 to 1989)	Catchment liming, total of 350t limestone applied. pre treatment - 4.4, Post treatment approx 6-7	Chlorophyll A concentrations (mg/m^3): Pre liming (n=5, Sept 1985 to Jan 1986): 0.2 (SD 0.2) Post liming (n=24) (March 1986 to March 1989): 1.7 (SD 1.2) Effect size (log ratio): 2.0 (SE 2.7) Diversity: diatom community changed; pre acidification fauna came back but also new taxa present which represent higher pH than before liming

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Blomqvist, et al. (1995). "Plankton and water chemistry in lake Njupfatet before and after liming." Canadian Journal of Fisheries and Aquatic Sciences 52(3): 551-565.</td><td>Njupfatet (see Anderson et all 1997 for species richness)</td><td>BA, 1 lake, enclosure experiments also took place within the lake with nutrient additions and species manipulation

13 samples in one year before liming and one year after.</td><td>Lake and outflows (into lake) of 2 small bogs limed. Lake limed with 16tonne finely ground calcite, 4 tonnes applied to outflows into lake.

pH 5.64 to 7.17 mean (range 5.3-6.0 to 6.6-7.6)</td><td>Total biomass (µg/L w. w.) (n=13 for both years)<table><tr><td>Before liming (1989)</td><td>314 (SD 196)</td></tr><tr><td>After liming (1990)</td><td>217 (SD 139)</td></tr></table>Effect size (log ratio): -0.37 (SE 0.26)</td></tr>
<tr><td>Bukaveckas, (1993). "Changes in primary productivity associated with liming and reacidification in an Adirondack lake." Environmental Pollution 79(2): 127-133.</td><td>Woods lake</td><td>BACI, 1 limed lake 1 control (another lake limed once and re-acidified next yr)

Control site selected due to having extensive background data on lake.

One year pre-liming sampled and six years post first liming.</td><td>Lake liming in 1985 and 1986 with 23 and 34.3 Mg respectively, 1989 two subcatchments limed with 6.7 Mg $CaCO_3$/ha

yearly mean pH before 5.1, after 5.5-6.9, control 4.9 -5.3</td><td>Chlorophyll A mg/m^3<table><tr><td></td><td>Before liming (1984)</td><td>After liming (1985 – 1990)</td></tr><tr><td>Treated</td><td>1.4</td><td>2.4 (0.6)</td></tr><tr><td>Control (darts lake)</td><td>1.9</td><td>2.0 (0.2)</td></tr></table>Effect size (log ratio): 0.46 (SE 0.43)
(log ratio of after to before for the treated site minus the after-before log ratio for the control).</td></tr>
<tr><td>Dickson, (1988). Liming of Lake Gårdsjön: an acidified lake in SW Sweden. Solna, National Swedish Environmental Protection Board. (number of species extracted from Stenson 1990)</td><td>Gårdsjön</td><td>BACI, 1 limed lake, 1 control

Control lake chosen as similar characteristics to limed lake.

Abundance data from two years prior to liming (1980-81) and four years after (1982-1985).</td><td>Lake liming
finely ground limestone spread over lake surface;100 tonnes in April 1982, 36.5 tonnes Aug 1985

pH increase from 4.7 - 4.8 before liming to 7.4 - 7.7 after. (Control lake showed slight decrease).</td><td>Phytoplankton abundance, mg w.w./l<table><tr><td></td><td>Before liming</td><td>After liming</td></tr><tr><td>Limed lake</td><td>0.2 (SD 0.1)</td><td>1.2 (SD 1.3)</td></tr><tr><td>Control lake</td><td>0.2 (SD 0.1)</td><td>0.2 (SD 0.4)</td></tr></table>Effect size (log ratio): 1.9 (SE 4.0)
(the log ratio for after to before liming in the limed lake minus the ratio in the control).

Number of species
Before liming(1981): 15.6; After liming average (1982-4): 31.3 (SD 10.8) (no control data available)
Effect size (log ratio): 0.70 (SE 0.23)</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr>
<td>Elser, et al. (1986). "Paul and Peter lakes: A liming experiment revisited." American Midland Naturalist 116(2): 282-295.</td>
<td>Peter Paul</td>
<td>CI, lake of two joined basins split in two and one side limed,

Control originally joined to limed lake, unclear how decided which side to lime.

Chlorophyll a concentrations from 8 years after last liming</td>
<td>Lake liming,
Two basins of lake divided by earthen bank and upstream basin limed, First limed in 1951 (2495kg hydrated lime), then limed every 2 to 7 yrs until last liming in 1976. Data from 8 years after last liming (in 1984)

pH pre-liming 5.9, post liming treatment 7.3-6.7, control 6.2-6.7</td>
<td>Chlorophyll A concentrations (µg/L)
<table><tr><td>Limed (Peter basin)</td><td>2.54</td></tr><tr><td>Control (Paul basin)</td><td>3.42</td></tr></table>
Effect size (log ratio): -0.30</td>
</tr>
<tr>
<td>Eriksson, et al. (1983). "Ecological Effects of Lime Treatment of Acidified Lakes and Rivers in Sweden." Hydrobiologia 101(1): 145-164.</td>
<td>various</td>
<td>BA, BACI data on two groups of neighbouring lakes one with controls and the other without

BA 2 lakes,
BACI (1 limed 2 controls)

But other lakes mentioned in paper and data not given</td>
<td>Lakes treated with fine crushed limestone

pH 4.9 to 6.1-6.8 in BA lakes unclear in other lakes</td>
<td>Observed number of phytoplankton species in summer samples
BA lakes
<table><tr><td>Lake</td><td>Before liming (1977)</td><td>After liming (average 1978 -80)</td></tr><tr><td>Blanksjon</td><td>27</td><td>36 (SD 16)</td></tr><tr><td>Iglafallssjon (downstream of Blaksjon)</td><td>29</td><td>37 (SD 10)</td></tr></table>Effect size 0.27 (SE 0.02)

BACI lakes
<table><tr><td>Lake</td><td>Before liming (1971-1976)</td><td>After liming (1971-1980)</td></tr><tr><td>Härsjön (limed)</td><td>14 (SD 7)</td><td>41 (SD 17)</td></tr><tr><td>Tvärsjön (control)</td><td>11 (SD 4)</td><td>15 (SD 4)</td></tr><tr><td>Ömmern (control)</td><td>45 (SD 5)</td><td>44 (SD 1)</td></tr></table>Effect size (log ratio): 0.92 (SE 0.65)</td>
</tr>
<tr>
<td>Hasselrot, et al. (1984). "Ecosystem shifts and reintroduction of Arctic char (Salvelinus salvelinus (L.)) after liming of a strongly acidified lake in southwestern Sweden." Institute of Freshwater Research Drottningholm</td>
<td>Stora Holmevatten</td>
<td>BA, 1 lake,

Data from one year prior to liming (one sample) and 4 years post liming (total of 15 samples)
Charr stocked after liming</td>
<td>Limed autumn 1981 with 1225 tons and 1989 with 657 tons, since limed continuously via lime dosers on affluent

pH about 4.5 to 7-8</td>
<td>Number of phytoplankton species
<table><tr><td>Pre liming</td><td>20</td></tr><tr><td>Post liming average</td><td>18 (SD 5)</td></tr></table>Effect size (log ratio): -0.11 (SE 0.24)

Phytoplankton biomass (wet weight in g.m^{-3})
<table><tr><td>Pre liming</td><td>0.04</td></tr><tr><td>Post liming average</td><td>0.10 (SD 0.12)</td></tr></table>Effect size (log ratio): 0.78 (SE 2.66)</td>
</tr>
</table>

<table>
<tr><td>Report 61: 78-92.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Hoernstroem, (1999). "Long-term phytoplankton changes in acid and limed lakes in SW Sweden." Hydrobiologia 394(1-3): 93-102.</td><td>Oemmern, Norway</td><td>BA, 1lake that has clear before after data presented, no clear before data for other lake</td><td>pH before liming 5.3, after liming 6.9, appart from first liming tributories limed</td><td>Number of phytoplankton taxa
<table><tr><td>Lake</td><td>Before liming</td><td>After liming</td></tr><tr><td>Ö. Nedsjön</td><td>34.2 (SD 5.0)</td><td>46.5 (SD 10.4)</td></tr><tr><td>Ömmern</td><td>41.1 (SD 1.08)</td><td>57.0 (SD 5.2)</td></tr></table>Effect size (log ratio): 0.32 (SE 0.07)
(average of the log ratio of after to before for the two lakes)

Phytoplankton volume
Lake Ommern, before liming: 0.16mm^3/l, after liming:0.35
Effect size (log ratio): 0.78</td></tr>
<tr><td>Hornstrom, et al. (1993). "Plankton and chemical physical development in 6 Swedish west-coast lakes under acidic and limed conditions." Canadian Journal of Fisheries and Aquatic Sciences 50(4): 688-702.</td><td>Swedish lakes:
Tvarsjon
Stora Harsjon
Stockasjon
Stora Svansjon
Skallingesjon
Bossjon
Stora Fargen</td><td>BA in 6 lakes,</td><td>Not given</td><td>Mean phytoplankton volume (mm^3/l) in study lakes July-August
<table><tr><td>lake</td><td colspan="3">Before liming</td><td colspan="3">After liming</td></tr><tr><td></td><td>mean</td><td>SD</td><td>n</td><td>mean</td><td>SD</td><td>n</td></tr><tr><td>Tvarsjon</td><td>0.27</td><td>0.31</td><td>9</td><td>0.19</td><td>0.18</td><td>6</td></tr><tr><td>Stora Harsjon</td><td>0.22</td><td>0.17</td><td>4</td><td>0.32</td><td>0.33</td><td>10</td></tr><tr><td>Stockasjon</td><td>0.3</td><td>0.31</td><td>7</td><td>0.38</td><td>0.18</td><td>4</td></tr><tr><td>Stora Svansjon</td><td>0.33</td><td>0.32</td><td>7</td><td>0.66</td><td>0.27</td><td>5</td></tr><tr><td>Skallingesjon</td><td>0.19</td><td>0.21</td><td>7</td><td>0.3</td><td>0.24</td><td>3</td></tr><tr><td>Bossjon</td><td>0.15</td><td>0.19</td><td>4</td><td>0.56</td><td>0.26</td><td>5</td></tr></table>Effect size (log ratio): 0.45 (SE0.20)
(average log ratio effect size across lakes)

Number of phytoplankton species (Average number per sample)
<table><tr><td>Before liming</td><td>15 (range 14 – 17)</td></tr><tr><td>2-4 yrs after liming</td><td>47 (range 40 – 54)</td></tr></table>Effect size (log ratio): 1.14</td></tr>
<tr><td>Holmgren, (2001). "Biomass-size distribution of the aquatic community in limed, circumneutral and acidified reference lakes." Water Air and Soil Pollution 130(1-4): 1751-1756.</td><td>Swedish lakes (from national liming program) Gyltigesjon, Stora Harsjon, Stensjon, Lien, Vastra Skalsjon, Kallsjon (all included in Persson 2008) Acid:Rotehogstjamen, Ovre</td><td>CI 6 limed, 2 acid lakes

Limed lakes part of national liming program, which lakes to lime not selected but study authors and not randomized. Controls selected as part of the national acid water monitoring program.</td><td>Limed lakes are part of national liming program and limed along the programs guidelines with first liming in 1977-1984 but details not given for each lake

Average pH acid 5.9 (0.0), limed 7.0 (0.2)</td><td>Phytoplankton biomass (mm^{3}per m^3)
<table><tr><td>Limed</td><td>328</td></tr><tr><td>Control</td><td>1173</td></tr></table>Effect size (log ratio): -1.27</td></tr>
</table>

<table>
<tr><td></td><td>Skarsjon</td><td></td><td></td><td></td></tr>
<tr><td>Iivonen, et al. (1995). "Chemical, biological and socio-economic approaches to the liming of Lake Alinenjärvi in southern Finland " Water, Air, & Soil Pollution 85(2): 937-942.</td><td>Alinenjarvi, Finland</td><td>BA, 1 lake,
One year before liming and two years after liming.</td><td>60 tons fine dry limestone spread over deepest parts in 1992

pH before 5.8-6.2, after 6.5-7.3,
limestone powder directly to lake</td><td>Number of phytoplankton taxa
<table><tr><td>1991 (pre liming)</td><td>1992 (post liming)</td><td>1993</td></tr><tr><td>26</td><td>34</td><td>26</td></tr></table>Effect size (log ratio): 0.30

Chlorophyll A concentrations remained <6µg/l before and after liming.</td></tr>
<tr><td>Molot, et al. (1990). "Response of Phytoplankton in Acidic Lakes in Ontario to Whole-Lake Neutralization." Canadian Journal of Fisheries and Aquatic Sciences 47, no(2): 422-431.</td><td>Bowland lake, Trout lake (along with data on nearby control lake Miskokway)</td><td>BA, BACI, 1 lake with only before data and 1 lake with before and after data and an unlimed control of similar characteristic.

Control close to second limed lake (Trout lake) but unclear how lakes chosen.

Separate data for both lakes, and control matched to only one of the limed lakes so data split up.</td><td>Bowland lake (BA)
Limed in August 1983

pH before 4.9, after 6.8

Trout lake (BACI)

Limed in May 1984
ph before 5.8, after 6.5, control 5.6</td><td>Bowland lake:
Number of phytoplankton taxa:
<table><tr><td>Pre-liming</td><td>37</td></tr><tr><td>Post-liming</td><td>46</td></tr></table>Effect size (log ratio): 0.22

Phytoplankton biovolumes (mean from monthly measurements during ice-free period of lake)
<table><tr><td>Pre-liming (June 1982 to July 1983)</td><td>0.21 (SD 0.16)</td></tr><tr><td>Post-liming (June 1984 to July 1985)</td><td>0.36 (SD 0.22)</td></tr></table>Effect size (log ratio): 0.54 (SE 0.34)

Trout lake:
Number of phytoplankton taxa:
<table><tr><td></td><td>Pre-liming</td><td>Post-liming</td></tr><tr><td>Treatment</td><td>63</td><td>58</td></tr><tr><td>Control</td><td>62</td><td>71</td></tr></table>Effect size (log ratio): -0.22

Phytoplankton biovoulumes (mean from monthly measurements during ice-free periods)
<table><tr><td></td><td>Pre-liming (Sept 1982 – May 1984)</td><td>Post-liming (June 1984- Nov 1985)</td></tr><tr><td>Treatment</td><td>0.52 (SD 0.24)</td><td>0.47 (SD 0.36)</td></tr><tr><td>Control</td><td>0.37 (SD 0.28)</td><td>0.36 (SD 0.22)</td></tr></table>Effect size (log ratio): -0.07 (SE 0.37)</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr>
<td>Persson, and Appelberg (2001). "Evidence of Lower Productivity in Long Term Limed Lakes as Compared to Unlimed Lakes of Similar pH." Water, Air, & Soil Pollution 130(1-4): 1769-1774.</td>
<td>Various in Sweden: Källsjön, N. Samamannasjon, Bosjon, Tryssjon, Vastra Skalsjon, Lien, Stensjon, Ejgdesjon, Langsjon, Stora Harsjon, Stengardshulasjon Gyslattasjon, Gyltigesjon, Nassjon, Blanksjon</td>
<td>CI, 14 limed lakes from the ISELAW long term monitoring, 7 acid Controls

Average pH acid 5.23, limed 6.70</td>
<td>Limed according to the national recommendations</td>
<td>Phytoplankton volume (mm^3/l)
<table>
<tr><td>Limed</td><td>0.21</td></tr>
<tr><td>Acid Control</td><td>0.29</td></tr>
</table>
Effect size (log ratio); 0.27

Number of phytoplankton species
<table>
<tr><td>Limed</td><td>78</td></tr>
<tr><td>Acid control</td><td>86</td></tr>
</table>
Effect size (log ratio): 0.44</td>
</tr>
<tr>
<td>Raddum, et al. (1986). "Liming the acid lake Hovvatn, Norway: A whole-ecosystem study." Water, Air, & Soil Pollution 31(3): 721-763.</td>
<td>Hovvatn, Norway</td>
<td>BA, CI no before data of control, 2 limed lakes 1 control

Control lake was a small lake that drained into the main limed lake.</td>
<td>Hovvatn limed on shore and over ice in winter with 200 tonne powdered limestone in 1981, Pollen limed with 40 tonnes

pH before 4.5, after 7.4-4.9</td>
<td>Mean volume of phytoplankton in the ice-free season at 3 sites before and after liming. Units: mm^3m^{-3}. Number of samples is given in parentheses.
<table>
<tr><td></td><td>1980 Pre liming</td><td>1981 Post liming</td><td>1982</td><td>1983</td></tr>
<tr><td>Hovvatn (limed)</td><td>29 (2)</td><td>57 (5)</td><td>95 (7)</td><td>72 (7)</td></tr>
<tr><td>Pollen (limed)</td><td>79 (2)</td><td>59 (5)</td><td>129 (7)</td><td>91 (7)</td></tr>
<tr><td>Lille Hovvatn (control)</td><td></td><td></td><td>103 (7)</td><td>148 (7)</td></tr>
</table>
Effect size (log ratio) from before and after data: 0.43 (SE 0.43) (average after liming divided by the average before liming for each lake and then averaged)
(Control impact data log ratio effect size: -0.40)

Number of species
<table>
<tr><td></td><td>1981(Post liming)</td><td>1982</td><td>1983</td></tr>
<tr><td>Hovvatn (limed)</td><td>32</td><td>28</td><td>33</td></tr>
<tr><td>Pollen (limed)</td><td>23</td><td>34</td><td>34</td></tr>
<tr><td>Lille Hovvatn (control)</td><td></td><td>28</td><td>28</td></tr>
</table>
Effect size (average number inlimed years and sites divided by average number in control site, logged; log ratio) 0.09</td>
</tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Scheider, and Dillon (1976). "Neutralization and fertilization of acidified lakes near Sudbury, Ontario." Water Pollution Research Canada.</td><td>Middle, Lohi, USA (Clearwater and Hannah as controls)</td><td>BACI, 2 control and 2 treatment lakes year before treatment and year after.

Unclear how lake was chosen.</td><td>Limed in 1973 by fine powdered calcium carbonate slurry over lake surface

pH control 4.3-4.5, treatment before 4.4-4.5, after, 6.2,7.0</td><td>Phytoplankton standing stock (standard unit/ml)<table><tr><td>Lake</td><td>1973</td><td>1974</td></tr><tr><td>Hannah</td><td>100</td><td>155</td></tr><tr><td>Middle</td><td>135</td><td>193</td></tr><tr><td>Clearwater</td><td>137</td><td>201</td></tr><tr><td>Lohi</td><td>210</td><td>355</td></tr></table>Effect size (log ratio): 0.03</td></tr>
<tr><td>Wahlström and Danilov (2003). "Phytoplankton successions under ice cover in four lakes located in north-eastern Sweden: effects of liming." Folia microbiologica, Jan 48(3): 379-384.</td><td>Aspen and Vialamptjarn limed lakes, Norway</td><td>CI, 2 limed lakes, 1 acid control

Unclear how limed and control lakes chosen</td><td>Details of liming not given, lakes not limed by authors.

pH limed: 6.4, 5.6, acid:4.4, details of liming not given</td><td>Chlorophyll a concentrations (ng/l)<table><tr><td>Aspen (limed)</td><td>Vialamptjärn (limed)</td><td>Storkorstjärn (control)</td></tr><tr><td>193 (SD 127)</td><td>147 (SD 107)</td><td>173 (SD 163)</td></tr></table>Effect size (log ratio): -0.02 (SE 0.29)

Number of species found<table><tr><td>Aspen (limed)</td><td>Vialamptjärn (limed)</td><td>Storkorstjärn (control)</td></tr><tr><td>26</td><td>18</td><td>11</td></tr></table>Effect size (log ratio): 0.69</td></tr>
</table>

E.2 studies not included within the meta-analysis

Study	Reason for exclusion from quantitative analysis/ Results
Angeler, D. G. and W. Goedkoop (2010). "Biological responses to liming in boreal lakes: an assessment using plankton, macroinvertebrate and fish communities." Journal of Applied Ecology 47(2): 478-486.	Numerical differences not given but results of statistical analysis stated as showing there was no difference in biomass same but richness was higher in limed
Appelberg, M. (1995). "Liming strategies and effects: The Lake Gyslattasjon case study." Liming of acidified surface waters: A Swedish synthesis: 353-361.	No before data available but statement that certain species only appeared after liming.
Edberg, F., P. Andersson, et al. (2001). "Reacidification Effects on Water Chemistry and Plankton in a Limed Lake in Sweden." Water, Air, & Soil Pollution 130(1-4): 1763-1768.	BA, 1 lake. Statement of before 12-29 taxa, after gradually increased to 40-50 but precise yearly data not given
Jarvinen, M., K. Kuoppamaki, et al. (1995). "Responses of phyto- and zooplankton to liming in a small acidified humic lake." Water, Air, & Soil Pollution 85(2): 943-948.	Phytoplankton abundance profile through water column different for limed and control but data only given for shallow or profile once fish had collapsed in control, so no comparable control data
Guhren, M., C. Bigler, et al. (2007). "Liming placed in a long-term	Core data - relative abundance of diatoms, absolute abundances cannot be

perspective: a paleolimnological study of 12 lakes in the Swedish liming program." Journal of Paleolimnology 37(2): 247-258.	extracted. Statement that there was recovery in different lakes with liming
Rhodes, T. E. (1991). "A paleolimnological record of anthropogenic disturbances at Holmes Lake, Adirondack Mountains, New York." Journal of Paleolimnology 5(3): 255-263.	Core data BA liming, increase in acid-phobic species in top sediment layer but cannot clearly identify before/after liming and no data presented.
Simola, H. (1986). Diatom responses to acidification and lime treatment in a clear-water lake: Comparison of two methods of analysis of a diatom stratigraphy. Diatoms and Lake Acidity J. P. Smol, R. W. Battarbee, R. B. Davis and J. Meriläinen, Junk Dordrecht, The Netherlands: 221-226.	Core data; increase in acid sensitive species in top 2mm but not possible to date core so cannot get confirmed before and after liming data.
Appelberg, M. and T. Svenson (2001). "Long-term ecological effects of liming - The ISELAW programme." Water Air and Soil Pollution 130(1-4): 1745-1750.	Persson and Appelberg 2001
Bell, R. T. and L. Tranvik (1993). "Impact of acidification and liming on the microbial ecology of lakes." Ambio 22(5): 325-330.	See Blomqvist et al 1995
Bellemakers, M. J. S. and H. Vandam (1992). "Improvement of breeding success of the moor frog (rana-arvalis) by liming of acid moorland pools and the consequences of liming for water chemistry and diatoms." Environmental Pollution 78(1-3): 165-171.	Changes in abundance of different types of diatoms, relative abundance of different taxa not changes in absolute abundance
Blomqvist, P. (1996). "Late summer phytoplankton responses to experimental manipulations of nutrients and grazing in unlimed and limed Lake Njupfatet, central Sweden." Archiv fuer Hydrobiologie 137(4): 425-455.	See Blomqvist et al 1995
Blomqvist, P. (1997). "Early summer phytoplankton responses to experimental manipulations of grazing and nutrients in unlimed and limed Lake Njupfatet, central Sweden." Archiv fuer Hydrobiologie 140(3): 321-346.	See Blomqvist et al 1995
Blomqvist, P., R. T. Bell, et al. (1993). "Pelagic ecosystem responses to nutrient additions in acidified and limed lakes in Sweden." Ambio. Stockholm 22(5): 283-289.	See Blomqvist et al 1995
Broberg, O. (1987). "Nutrient responses to the liming of lake Gårdsjön." Hydrobiologia 150(1): 11-24.	See Dicksons 1988
Broberg, O. (1988). "Delayed Nutrient Responses to the Liming of Lake Gardsjon, Sweden." Ambio AMBOCX 17(1): 22-27.	See Dicksons 1988
Bukaveckas, P. A. (1989). "Effect of calcite treatment on primary producers in acidified Adirondack lake. II. Short-term response by phytoplankton communities." Canadian Journal of Fisheries and Aquatic Sciences 46(2): 352-359.	See Bukaveckas 1993
Bukaveckas, P. A. (1988). "Effects of lake liming on phytoplankton production in acidic Adirondack lakes." Water, Air, & Soil Pollution 41(1): 223-240.	See Bukaveckas 1993

Bukaveckas, P. A. and C. T. Driscoll (1991). "Effects of whole-lake base addition on the optical-properties of 3 clearwater acidic lakes." Canadian Journal of Fisheries and Aquatic Sciences 48(6): 1030-1040.	See Bukaveckas 1993
Cameron, N. G. (1995). "The representation of diatom communities by fossil assemblages in a small acid lake." Journal of Paleolimnology 14(2): 185-223.	Datoms before and after liming , but only presents percentages of different species over time, cannot extract absolute abundances
Flower, R. J., N. G. Cameron, et al. (1990). "Post-1970 Water-Chemistry Changes and Palaeolimnology of Several Acidified Upland Lakes in the U.K." Philosophical Transaction of the Royal Society of London. Series B. Biological Sciences PTRBAE 327(1240): 427-433.	Core data – relative abundance of species, cannot extract changes in absolute abundances of phytoplankton
Hoernstroem, E. (2002). "Phytoplankton in 63 limed lakes in comparison with the distribution in 500 untreated lakes with varying pH." Hydrobiologia 470(1-3): 115-126.	Only data presented for taxa where there was a difference between limed and acid , therefore cannot be used to assess if overall there was a difference with liming or not
Hultberg, H. and P. Grennfelt (1986). "Gårdsjön Project: lake acidification, chemistry in catchment runoff, lake liming and microcatchment manipulations." Water, Air, & Soil Pollution 30(1): 31-46.	See Dicksons 1988
Hultberg, H. and I. Andersson (1982). "Liming of acidified lakes: Induced long-term changes." Water, Air, & Soil Pollution 18(1): 311-331.	Data already extracted for only lake presented, See Dicksons 1988
Leavitt, P. R., S. R. Carpenter, et al. (1989). "Whole-Lake Experiments: The Annual Record of Fossil Pigments and Zooplankton." Limnology and Oceanography LIOCAH 34(4): 700-717.	Fossil pigment levels from before and after liming in both lakes, not actually phytoplankton abundance
Molot, L. A., P. J. Dillon, et al. (1990). "Whole-Lake and Nearshore Water Chemistry in Bowland Lake, Before and After Treatment with CaCO sub(3)." Canadian Journal of Fisheries and Aquatic Sciences 47, no(2): 412-421.	See Molot et al 1990b
Norberg, M., C. Bigler, et al. (2008). "Monitoring compared with paleolimnology: implications for the definition of reference condition in limed lakes in Sweden." Environmental monitoring and assessment 146(1-3): 295-308.	Diatom inferred pH changes (mainly statements of change). Does not present if there was a change in abundance or diversity of phytoplankton
Ohl, L. E., R. A. Gont, et al. (1990). "Diatom response to liming of a temperate, brown water lake." Can. J. Bot./J. Can. Bot. 68(2): 347-353.	See Elser et al 1986
Pettersson, A. and P. Blomqvist (1992). "Bioassay for Phosphate Demand in Phytoplankton From Acidified Lakes: Lake Njupfatet, an Example of Phosphate Deficiency Induced by Liming." Hydrobiologia HYDRB8 246(2): 99-110.	See Blomqvist et al 1995
Porcella, D. B. (1988). "Update on the Lake Acidification Mitigation Project (LAMP)." Water, Air, and Soil Pollution WAPLAC 41(1-4): 43-51.	See Bukaveckas 1993
Rask, M., M. Jarvinen, et al. (1996). "Limnological responses to the collapse of the perch population in a small lake." Annales Zoologici Fennici 33(3-4): 517-524.	BA but fish pop^{n} collapsed in control

Renberg, I. and T. Hellberg (1982). "The pH history of lakes in southwestern Sweden, as calculated from the subfossil diatom flora of the sediment." Ambio 11(1): 30-33.	Percentages of different groupings of diatoms over time, extractable data in Alenäs et al 1991
Renberg, I. and H. Hultberg (1992). "A paleolimnological assessment of acidification and liming effects on diatom assemblages in a Swedish lake." Canadian Journal of Fisheries and Aquatic Sciences 49(1): 65-72.	Relative abundance of different diatom groups over time, extractable data in Alenäs et al 1991
Rosén, P. and D. Hammarlund (2007). "Effects of climate, fire and vegetation development on Holocene changes in total organic carbon concentration in three boreal forest lakes in northern Sweden." Biogeosciences 4(6): 975-984.	Diatom relative abundance, species richness - cannot extract accurate before after data because of scale
Stensdotter-Blomberg, U. (1998). "Factors controlling pelagic populations of ciliates and heliozoans - late summer investigations in an acidic lake before and after liming." Journal of Plankton Research 20(3): 423-442.	See Blomqvist et al 1995
Stenson, J. A. E. (1990). "Creating conditions for changes in prey community structure by Chaoborus spp. in a lake in Sweden." Hydrobiologia 198: 205-214.	See Dicksons 1988
Stenson, J. A. E. and J. E. Svensson (1995). "Changes of planktivore fauna and development of zooplankton after liming of the acidified lake Gårdsjön." Water, Air, and Soil Pollution 85(2): 979-984.	See Dicksons 1988
Tranvik, L. J., W. Graneli, et al. (1994). "Microbial activity in acidified and limed humic lakes." Canadian Journal of Fisheries and Aquatic Sciences 51(11): 2529-2536.	Microbial activity not general phytoplankton or zooplankton
Uutala, A. J. and J. P. Smol (1996). "Paleolimnological reconstructions of long-term changes in fisheries status in Sudbury area lakes." Canadian Journal of Fisheries and Aquatic Sciences 53(1): 174-180.	cores, relative abundance
Vrede, K. (1996). "Regulation of bacterioplankton production and biomass in an oligotrophic clearwater lake - The importance of the phytoplankton community." Journal of Plankton Research 18(6): 1009-1032.	See Blomqvist et al 1995
Waervaagen, S. B. and J. P. Nilssen (2003). "Major changes in pelagic rotifers during natural and forced recovery from acidification." Hydrobiologia 499(1-3): 63-82.	percentages in different taxxa of pelagic rotifers
Willen, T. (1980). "Phytoplankton from Swedish lakes. 3. Lake Hundsjoen and other kettle lakes of Central Sweden." Archiv fuer Hydrobiologie 89(1/2): 135-139.	description changes in phytoplankton spp, no quantitative data

Appendix F. Summary of articles reporting data on benthic organisms

F.1 Benthic invertebrate articles included within the meta-analysis

<table>
<tr><th>Study</th><th>Location</th><th>Study Design</th><th>Liming /pH change</th><th>Results</th></tr>
<tr>
<td>Bradt, P. T. (1996). "Limestone to mitigate lake acidification: macrozoobenthos response in treated and reference lakes." Hydrobiologia 317(2): 115-126.</td>
<td>White dear lake, USA</td>
<td>BACI, 1 lake treated, 1 control

Control picked as similar in physical characteristics, biology and water chemistry.

Data from 1 year prior to liming (spring, summer and autumn samples) and four years after liming.</td>
<td>Lake liming:100tons agricultural limestone spread on the ice of lake in Feb 1985, 15.1 tons also added in Oct 1987

pH treated lake: before 5.5 (range 4.7-6.6), after 6.6 (range 4.3-8.0)</td>
<td>Macrozoobenthos total taxa richness per 0.023 m^2
<table>
<tr><th>Lake</th><th>Before liming (1984, n=3)</th><th>After liming (1985-1988, n=12)</th></tr>
<tr><td>White deer lake (limed)</td><td>14 (SD 1)</td><td>23 (SD 5)</td></tr>
<tr><td>Bruce lake (control)</td><td>13 (SD2)</td><td>19 (SD 4)</td></tr>
</table>
Effect size (log ratio): 0.19 (SE 0.26)

Macrozoobenthos abundance (number per 0.023m^2)
<table>
<tr><th>Lake</th><th>Before liming (1984, n=3)</th><th>After liming (1985-1988, n=12)</th></tr>
<tr><td>White deer lake (limed)</td><td>69 (SD 12)</td><td>153 (SD 70)</td></tr>
<tr><td>Bruce lake (control)</td><td>57 (SD 9)</td><td>99 (SD 68)</td></tr>
</table>
Effect size (log ratio):0.80 (SE 0.45)</td>
</tr>
<tr>
<td>Carbone, J., et al. (1998). "Effects of changes in acidity on aquatic insects in rocky littoral habitats of lakes near Sudbury, Ontario." Restoration Ecology 6(4): 376-389.</td>
<td>Whirligig and Little Whitepine lakes, USA</td>
<td>BACI, 2 limed lakes and 1 control

Unclear how control and limed lakes chosen

Data from two years prior to liming (1987,1988) and five years after liming (1990 – 1994) (limed in end 1989)</td>
<td>Lake liming with powdered limestone Autumn 1989 with aim of bringing pH to approx. 6.5. One of the lakes relimed in 1993

pH treated: before liming 5.2 (4.8 to 5.6), after liming 6.1 (5.4 to 6.7). Control average pH 5 before and after liming (range 4.9 to 5.1)</td>
<td>Presence of aquatic insects in the lakes
<table>
<tr><th>Lake</th><th>Before liming</th><th>After liming</th></tr>
<tr><td>Control</td><td>16 (SD 2)</td><td>14 (SD 4)</td></tr>
<tr><td>Limed (Whirligig)</td><td>17 (SD 3)</td><td>15 (SD 4)</td></tr>
<tr><td>Limed (Little Whitepine)</td><td>13 (SD 4)</td><td>10 (SD 4)</td></tr>
</table>
Effect size (log ratio): - 0.08 (SE 0.26)</td>
</tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Desgranges, J. L. and C. Gagnon (1994). "Duckling response to changes in the trophic web of acidified lakes." Hydrobiologia 280: 207-221.</td><td>Lac au Cochon</td><td>BA, 1 lake (but before data presented combined with another acid lake that was not treated)</td><td>Lake liming with 5 T HCO_3 in $3x10^5$ m^3 water in 1986

pH before liming 4.8, after liming 6 (unlimed control 5)</td><td>Abundance of benthic aquatic insects (number per 10 census points)<table><tr><td>Before liming (combined mean from limed lake before liming (1985) and unlimed control lake in 1984)</td><td>85</td></tr><tr><td>After liming (Data from limed lake year after liming 1986)</td><td>283</td></tr></table>Effect size (log ratio): 1.20</td></tr>
<tr><td>Evans, R. A. (1989). "Response of limnetic insect populations of two acidic, fishless lakes to liming and brook trout (Salvelinus fontinalis) introduction." Canadian Journal of Fisheries and Aquatic Sciences 46(2): 342-351.</td><td>Woods lake, USA</td><td>BA 2 lakes
One sample in year before liming (July 1984) and one sample year after liming (July 1985</td><td>Lake limed
Calcium carbonate slurry was applied in May 1985 to both lakes

pH increased from below 5 to above 9 but then declined to below 8</td><td>Mean densities (number per m^2)of Hemiptera (Corixidae and Notonectidae) determined from benthis sweep net samples in Woods lake and Cranberry Pond<table><tr><td>Lake</td><td>Before liming</td><td>After Liming</td></tr><tr><td>Woods</td><td>1.13</td><td>0.48</td></tr><tr><td>Cranberry</td><td>2</td><td>0.18</td></tr></table>Effect size (log ratio): -1.55 (SE 1.25)</td></tr>
<tr><td>Hasselrot, B., et al. (1984). "Ecosystem shifts and reintroduction of Arctic char (Salvelinus salvelinus (L.)) after liming of a strongly acidified lake in southwestern Sweden." Institute of Freshwater Research Drottningholm Report 61: 78-92.</td><td>Stora Holmevatten</td><td>BA, 1 lake,

Data from one year prior to liming (one sample) and 4 years post liming (total of 15 samples)
Charr stocked after liming</td><td>Limed autumn 1981 with 1225 tons and 1989 with 657 tons, since limed continuously via lime dosers on affluent

pH about 4.5 to 7-8</td><td>Benthic biomass (wet weight, g/m^2):<table><tr><td>Before liming (1979, 2 samples)</td><td>After liming (1980 – 1983, 10 samples)</td></tr><tr><td>2.2 (SD 1.9)</td><td>5.6 (SD 4.1)</td></tr></table>Effect size (log ratio): 0.94 (SE 1.07)</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Holmgren, K. (2001). "Biomass-size distribution of the aquatic community in limed, circumneutral and acidified reference lakes." Water Air and Soil Pollution 130(1-4): 1751-1756.</td><td>Swedish lakes (from national liming (ISELAW) program) Gyltigesjon, Stora Harsjon, Stensjon, Lien, Vastra Skalsjon, Kallsjon (all included in Persson 2008)</td><td>CI 6 limed, 2 acid lakes

Limed lakes part of national liming program, which lakes to lime not selected but study authors and not randomized. Controls selected as part of the national acid water monitoring program.</td><td>Limed lakes are part of national liming program and limed along the programs guidelines with first liming in 1977-1984 but details not given for each lake

Average pH acid 5.9 (0.0), limed 7.0 (0.2)</td><td>Biomass of benthic invertebrates (g/m^2)
<table><tr><td>Limed lakes</td><td>1.69</td></tr><tr><td>Control lakes</td><td>7.25</td></tr></table>
Effect size (log ratio):-1.46</td></tr>
<tr><td>Hultberg, H. and I. Andersson (1982). "Liming of acidified lakes: Induced long-term changes." Water, Air, & Soil Pollution 18(1): 311-331.</td><td>Bredvatten and Skitjärn, Sweden</td><td>BA
Data from two lakes presented as examples. Unclear how it was decided which lakes to present</td><td>Lake liming Bredvatten limed with 40 metric ton and Skitjarn with 46 metric ton

pH increased to >6 in all lakes</td><td>Biomass of benthic organisms (g/m^2) on the profundal bottom
<table><tr><td>Lake</td><td>Before (1973)</td><td>After (1974-1980)</td></tr><tr><td>Bredvatten</td><td>5.8 (SD 5.9)</td><td>4.7 (SD 2.7)</td></tr><tr><td>Skitjarn</td><td>3.3</td><td>3.3 (SD 1.3)</td></tr></table>Effect size (log ratio): -0.11 (SE 0.41)</td></tr>
<tr><td>Keller, W., et al. (1990). "Changes in the Zoobenthos Community of Acidified Bowland Lake after Whole-Lake Neutralization and Lake Trout (Salvelinus namaycush) Reintroduction." Canadian Journal of Fisheries and Aquatic Science 47: 440-444</td><td>Bowland lake, USA</td><td>BA 1 lake</td><td>Lake lime in August 1983

pH before 4.9, after 6.8</td><td>Number of benthic invertebrate taxa
<table><tr><td>Before liming 1982</td><td>After liming
1984 1985</td></tr><tr><td>51</td><td>58 66</td></tr></table>Effect size (log ratio): 0.20

Biomass of zoobenthos (mg.m^{-2})
<table><tr><td>Before (1982)</td><td>1030</td></tr><tr><td>After (1984,1985)</td><td>913</td></tr></table>Effect size (log ratio): - 0.10</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Milner, A. G. P. and R. J. Aston (1995). "Pre- and post-liming aquatic communities and trout diets." Chemistry and ecology. London. 9: 3-4.</td><td>Loch Fleet, UK</td><td>BA 1 lake
(data from after liming but before fish stocking)</td><td>Catchment liming, total of 350t limestone applied.
pre treatment - 4.4, Post treatment approx 6-7</td><td>Benthic invertebrates (number per m^3)<table><tr><td>Sampling method</td><td>Before</td><td>After</td></tr><tr><td>Shore</td><td>2630</td><td>880</td></tr><tr><td>Airlift</td><td>1140</td><td>190</td></tr><tr><td>Petersen</td><td>100</td><td>30</td></tr></table>Effect size (log ratio): -1.4 (SE 0.38)
(average across sampling methods)</td></tr>
<tr><td>Raddum, et al. (1986). "Liming the acid lake Hovvatn, Norway: A whole-ecosystem study." Water, Air, & Soil Pollution 31(3): 721-763.</td><td>Hovvatn, Norway</td><td>BA, 1 limed lake

Data from one year before liming (1977) and three years after liming (1981 -83)</td><td>limed on shore and over ice in winter with 200 tonne powdered limestone in 1981,

pH before 4.5, after 7.4-4.9</td><td>Abundance of benthic invertebrates (individuals per m^2) (average across depths)<table><tr><td>Before liming (1977)</td><td>After liming</td></tr><tr><td>3000 (SD3700)</td><td>6900 (SD 7100)</td></tr></table>Effect size (log ratio): 0.85 (SE 2.47)</td></tr>
<tr><td>Raddum, et al. (1984). "Effects of lime treatment on the benthos of lake Sondre-Boksjo Norway Sweden." Institute of Freshwater Research Drottningholm Report(61): 167-176.</td><td>Sondre-Boksjo, Norway</td><td>CI, 1 limed lake, 1 control

Control site is upstream lake from limed lake.</td><td>Limed along the shoreline with 9000tons calcium carbonate in July 1980

pH went from 4.5-4.8 to 6.7 -7.0, control 4.5 -4.8</td><td>Mean number of animals caught per minute sampling in Autumn<table><tr><td>Limed lake (1980-82, 2 sites)</td><td>1.3 (SD 0.3)</td></tr><tr><td>Control lake (1980-82, 1site)</td><td>5.7 (SD 4.4)</td></tr></table>Effect size (log ratio): 1.45 (SE 1.63)

Number of taxa of Coloptera, Hemiptera and Odonata occurring<table><tr><td></td><td>Control</td><td>Limed Site 1</td><td>Site 2</td></tr><tr><td>before</td><td>8</td><td>12</td><td>10</td></tr><tr><td>after</td><td>8</td><td>8</td><td>12</td></tr></table>Effect size (log ratio): -0.11</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rask, et al. (1996). "Limnological responses to the collapse of the perch population in a small lake." Annales Zoologici Fennici 33(3-4): 517-524.</td><td>Iso Valkjärvi, Finland</td><td>BACI, 1 lake divided into two with a plastic sheet. One half limed, other control.

Data from 1 year before liming (1990) and 1 year after (1991) (There was a major fish kill in the control basin in 1992 so data after this point not included)</td><td>One half of lake limed in May 1991

pH details not given</td><td>Mean total biomass of zoobenthos (g.m^{-2})<table><tr><td></td><td>Before liming (1990)</td><td>After liming (1991)</td></tr><tr><td>Limed basin</td><td>6.2 (range 3.2-9.2)</td><td>8.1 (range 6.1-10.1)</td></tr><tr><td>Control basin</td><td>6.9 (range 5.6-8.2)</td><td>7.2 (range 4.3 – 12.6)</td></tr></table>Effect size (log ratio): 0.22</td></tr>
<tr><td>Scheider, and Dillon (1976). "Neutralization and fertilization of acidified lakes near Sudbury, Ontario." Water Pollution Research Canada.</td><td>Middle, Lohi, USA (Clearwater and Hannah as controls)</td><td>BACI, 2 control and 2 treatment lakes year before treatment and year after.

Unclear how lake was chosen.</td><td>Limed in 1973 by fine powdered calcium carbonate slurry over lake surface

pH control 4.3-4.5, treatment before 4.4-4.5, after, 6.2,7.0</td><td>Bethic standing stock (number per m^{2})<table><tr><td>Lake</td><td>Before liming 1973</td><td>After liming 1974</td></tr><tr><td>Lohi (limed)</td><td>1096</td><td>427</td></tr><tr><td>Mlddle (limed)</td><td>654</td><td>96</td></tr><tr><td>Clearwater (control)</td><td>1053</td><td>5331</td></tr><tr><td>Hannah (control)</td><td>1172</td><td>1190</td></tr></table>Effect size (log ratio): -2.25</td></tr>
<tr><td>Schnell, (2001). "The Chironomid (Diptera) Subfossil Record of Lille Hovvatn (Norway), with a Comparison with a Similar Study in Adjacent Store Hovvatn." Water, Air, & Soil Pollution 130: 817-824</td><td>Hovvatn, Norway</td><td>CI, 1 lime lake, 1 control

Control lake upsteam of limed lake.</td><td>Lake limed since 1981</td><td>Number of taxa found in sediment samples<table><tr><td>Limed</td><td>29</td></tr><tr><td>Control</td><td>28</td></tr></table>Effect size (log ratio): 0.04</td></tr>
</table>

F.2 Benthic invertebrate articles not included within the meta-analysis

Studies were statements were made but numerical data could not be extracted	
Article	Reason for exclusion from meta-analysis/ results found
Angeler, D. G. and W. Goedkoop (2010). "Biological responses to liming in boreal lakes: an assessment using plankton, macroinvertebrate and fish communities." Journal of Applied Ecology 47(2): 478-486.	Only gives significance of any changes not actual change. Uses data from main Swedish datasets to differences. States there is no significant differences (biomass or species richness) in benthic invertebrates with liming
Appelberg, M. and T. Svenson (2001). "Long-term ecological effects of liming - The ISELAW programme." Water Air and Soil Pollution 130(1-4): 1745-1750.	Significance of changes in 14 lakes in Swedish national liming program but no data on what actual change was, other papers contain more information. Statement that the number of species in sub-littoral and profundal areas decreased but littoral increased, no significant changes in abundance.
Iivonen, P., T. Järvenpää, et al. (1995). "Chemical, biological and socio-economic approaches to the liming of Lake Alinenjärvi in southern Finland " Water, Air, & Soil Pollution 85(2): 937-942.	Only provides statement of changes not quantitative data. States there is increasing trend in biomass and abundance but not continued 2yrs after liming and little change in composition
Nyberg, P. (1995). "Liming strategies and effects: The Lake Vastra Skalsjon case study." Liming of acidified surface waters: A Swedish synthesis: 328-338.	Statements of if specific species increased or decreased but does not give numeric data.
Norberg, M., C. Bigler, et al. (2008). "Monitoring compared with paleolimnology: implications for the definition of reference condition in limed lakes in Sweden." Environmental monitoring and assessment 146(1-3): 295-308.	Quantitative data not given. Impact of liming from monitoring and paleolimnology: 4/5 lakes with data on benthic organisms showed increase after liming, in one the population was stable,
Prejs, K. and S. Lazarek (1988). "Benthic Nematodes in Acidified Lakes: Case of a Neglected Grazer." Hydrobiologia 169(2): 193-197.	Benthic nematodes decreased after liming but full numerical details not given
Articles not included within the analysis and reason why:	
Article	Reason
Fjellheim, A., A. Tysse, et al. (2007). "Fish Stomachs as a Biomonitoring Tool in Studies of Invertebrate Recovery." Water, Air, & Soil Pollution: Focus 7(1-3): 293-300.	Only changes in relative percentage abundance of different taxa not absolute changes in abundance. Or overall changes in abundance.
Fjellheim, A., A. Tysse, et al. (2001). "Reappearance of highly acid-sensitive invertebrates after liming of an alpine lake ecosystem." Water Air and Soil Pollution 131(1-4 Part 3): 1391-1396.	Data within Fjellheim et al 2007
Raddum, G. G. and A. Fjellheim (1995). "Effects of Liming and Acid Surface Water on the Mayfly Leptophlebia vespertina in Lake Hovvatn." Water Air and	Effect on the may fly Leptophlebi only not wider taxonomic group

Soil Pollution 85(2): 961-966.	
Appelberg, M. (1995). "Liming strategies and effects: The Lake Gyslattasjon case study." Liming of acidified surface waters: A Swedish synthesis: 353-361.	No before data available
Brown, D. J. A., G. D. Howells, et al. (1988). "Loch Fleet - a research watershed liming project." Water, Air, and Soil Pollution 41(1-4): 25-41.	Data within Millner and Aston 1995
Foster, G. N. (1991). "Aquatic Beetle Population Changes Associated with Recreating a Trout Fishery by Liming a Lake Catchment." Archiv fuer Hydrobiologie AHYBA4 122(3): 313-322.	Data within Millner and Aston 1995
Battarbee, R. W., N. A. Logan, et al. (1992). Other Aquatic Biology: Fora and Fauna. Restoring Acid Waters: Loch Fleet 1984-1990. G. Howells and T. R. K. Dalziel.	Data within Millner and Aston 1995

Appendix G. Summary of articles reporting on macrophytes

Paper	Study design	Results	Location
Alenäs, I., B. I. Andersson, et al. (1991). "Liming and reacidification reactions of a forest lake ecosystem, Lake Lysevatten, in SW Sweden." Water, Air, & Soil Pollution 59(1-2): 55-77.	1 lake, before-after liming, description of changes	*Sphagnum* species decreased after liming, Mougeotia disappeared with liming	Lysevatten, Sweden
Battarbee, R. W., N. A. Logan, et al. (1992). Other Aquatic Biology: Fora and Fauna. Restoring Acid Waters: Loch Fleet 1984-1990. G. Howells and T. R. K. Dalziel.	1 lake, before-after liming, data on percentage frequency with Ekman grab sampler	Number of aquatic macrophyte species increased after liming (from 11 to 20), although the newly established taxa remained a minor component of the community. *Sphagnum auriculatum* decreased in abundance (percentage occurrence before liming 54.2%, 2 yrs after liming: 7.6%). *Juncus bulbosus* increased but not to high levels (0.9 to 3.8%)	Loch Fleet, UK
Brandrud, T. E. and J. G. M. Roelofs (1995). "Enhanced Growth of the Macrophyte Juncus bulbosus in S Norwegian Limed Lakes. A Regional Survey." Water Air and Soil Pollution 85(2).	Control impact study, data from 35 limed lakes and 20 acidic reference lakes	*Juncus bulbosus* more frequent in limed lakes, in 2 of 3 regions surveyed (coverage 63-73% in the limed lakes; 15-18% in the unlimed lakes, in the other area limed lake coverage 26%, acidic lake 19%). Also denser growth *J. bulbosus*, original isoetid vegetation disappeared in areas of dense population. Highest species diversity in long term limed lakes and a (re-)establishment of some acid-intolerant species such as *Myriophyllum alterniflorum* and *Potamogeton spp*.	Multiple lakes all over Norway
Dorland, E., L. J. L. van den Berg, et al. (2005). "Catchment Liming to Restore Degraded, Acidified Heathlands and Moorland Pools." Restoration Ecology 13(2): 302-311.	2 lakes, Before, after liming data Map of change in distribution macrophytes	Small positive trends in the number of Red List and characteristic plants species of wet heaths. No significant positive correlation between the number of plant species and years since liming in either site. Abundant growth of *Juncus bulbosus* and several acid tolerant Sphagnum species disappeared following the liming.	Bieze and Schaopedobbe, Netherlands
Grahn, O. (1986). "Vegetation structure and primary production in	1 lake before and after liming	*Sphagnum* disappeared after liming, *Lobelia dortmanna* and *Isoetes lacustris* increased	Lake Gårdsjön, Sweden

acidified lakes in southwestern Sweden." Experientia 42(5): 465-470.			
Hagley, C. A., D. Wright, et al. (1996). "Changes in aquatic macrophytes after liming Thrush Lake, Minnesota." Restoration Ecology 4(3): 307-312.	1 lake, before and after liming	*Sphagnum platyphyllum* was completely eliminated from the lake. The charophyte, *Nitella*, that originally shared dominance in the deep littoral zone with *S. platyphyllum*, decreased in importance. Two vascular plants, *Potamogeton pusillus* and *Najas flexilis*, first found in the lake the year after liming and were abundant for 2 years after liming	Thursh lake, USA
Jackson, M. B., E. M. Vandermeer, et al. (1990). "Effects of Neutralization and Early Reacidification on Filamentous Algae and Macrophytes in Bowland Lake." Canadian Journal of Fisheries and Aquatic Sciences 47, no(2): 432-439.	1 lake, before and after liming	Extensive growths of filamentous algae were essentially eliminated within one year of liming.	Bowland lake, Canada
Roelofs, J. G. M., T. E. Brandrud, et al. (1994). "Massive expansion of *Juncus-bulbosus* l after liming of acidified SW Norwegian lakes." Aquatic Botany 48(3-4): 187-202.	CI study, 6 limed lakes and 5 acidic reference lakes	Limed lakes far high biomass macrophytes (1156 g dry weight per m^2 compared to 84). Largely due *Juncus bulbosus* (biomass of all other macrophytes lower in limed lakes), which dominated limed lakes (except for the most exposed shores of large lakes and the lakes limed after 1990). Acid lakes dominated by isoetid vegetation.	Various, Norawy
Roelofs, J., E. Brouwer, et al. (2002). "Restoration of aquatic macrophyte vegetation in acidified and eutrophicated shallow soft water wetlands in the Netherlands." Hydrobiologia 478(1): 171-180.	BA liming, 2 lakes,	No re-establishment of soft water macrophytes occurred and the dominant Sphagnum species and *J. bulbosus* spread even further. Regular liming of nitrogen-saturated sediments with accumulation of organic matter led to mobilisation of nutrients and eutrophication of the water layer (Bellemakers et al., 1990). Liming after removal of accumulated organic, shows strong decline of *J. bulbosus* and a strong increase of soft water species	Scherpven and Padvindersven, Netherlands
Weiher, E. R., C. W. Boylen, et al. (1994).	2 lakes before and after liming	Seven new species were found after calcite addition, one of these, *Potamogeton epihydrus*	Cranbery pond and woods lake,

"Alterations in aquatic plant community structure following liming of an acidic Adirondack lake." Canadian Journal of Fisheries and Aquatic Sciences 51(1): 20-24.		became the single most abundant species. Sphagnum sp. and Utricularia geminiscapa were extirpated from the lake within 5 years of the initial treatment. Total coverage decreased from 47.62 per cent in 1981 to 22.61 per cent in 1991. The floating-leafed plants and canopy-formers increased in their total coverage and relative abundance	USA
Lucassen, E., P. Spierenburg, et al. (2009). "Alkalinity generation and sediment CO2 uptake influence establishment of Sparganium angustifolium in softwater lakes." Freshwater Biology 54(11): 2300-2314.	Liming of isolated plots not the whole lake	Floating leaves of *S. angustifolium* appeared in the limed plots in 2001. No seedlings of *S. angustifolium* were found outside the plots.	Lake Dybingen, Norway
Howells etal 1992		Data within Battarbee 1992	Loch Fleet, UK
Roelofs etal 1995		Data within Roelofs et al 1994	