SUPPORTING INFORMATION

Accounting for the Biogeochemical Cycle of Nitrogen in Input-Output Life Cycle Assessment

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S.1 Background

S.1.1 The Biogeochemical cycle of N

Nitrogen is a crucial building block for existence of life and various terrestrial/aquatic ecosystems. It is considered to be a limiting factor for net primary production (NPP) in the biosphere, thus emphasizing the need for availability of nitrogen. Nitrogen exists in various forms in the biosphere but not all its forms are useful [18]. Based on the utility, nitrogen is defined into two basic forms : "inert" and "reactive". Inert nitrogen is the form that cannot be used by plants or other organisms for production purposes (except for industrial use of gaseous nitrogen). "Reactive" nitrogen on the other hand is the form of nitrogen than can be taken up by plants and living beings and used for production [13]. The largest pool of nitrogen exists in the atmosphere as N_2 gas which is "inert" nitrogen and cannot be directly used for production in ecosystem or anthropogenic systems. The biogeochemical cycle of nitrogen is the major mechanism by which the nitrogen pool from atmosphere becomes available in useful form to living beings. The transformation of inert nitrogen to reactive nitrogen involves many processes like nitrification, ammonification, etc. which change the oxidation state of nitrogen. Due to the existence of nitrogen at valence states ranging from -3(NH_3) to +5 (NO_3^-) numerous transformations of nitrogen are possible. The energy released during these transformations are utilized by different organisms for their metabolic activities [18]. Therefore, these microbial actions play a significant role in the circulation of N in the geobiosphere. The natural processes which are involved in the nitrogen cycle are : N_2 fixation, bacterial degradation, nitrification and denitrification. Nitrogen fixation is mainly the conversion of "inert" nitrogen to "reactive" nitrogen through natural processes of lightning or by free living and symbiotic microbes. The fixed nitrogen is further converted to NH_4^+ in a process called ammonification. In presence of nitrifying bacteria like Nitrosomonas, ammonium ions are converted to nitrate ions. This process of the nitrogen cycle is called as nitrification. Further, through the process of denitrification fixed nitrogen is returned to the atmospheric pool in form of N_2 and some loss of reactive N as N_2O thus closing the nutrient cycle. The natural nitrogen cycle provides important nutrients to plants and animals, thus also supporting human existence. Over the last few decades, due to the increased demand for food and other products that depend on reactive nitrogen its use and flow into the biosphere has increased tremendously [13, 12, 19]. However, the

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anthropogenic systems do not address full circulation and closing of nutrient cycle properly. This dramatic change makes it important to understand the relation between anthropogenic activities and the nitrogen cycle to maintain sustainable circulation of the N nutrient in the geobiosphere.

S.2 Anthropogenic System and the Nitrogen Cycle

Reactive nitrogen being the limiting factor for the production of food and other goods, it has witnessed increased demand for sustaining human needs. Crop production is the single most important factor that has changed global nitrogen flow [17, 11]. The invention of Haber-Bosch process and production of fertilizer greatly increased the availability of reactive N for plants and reduced dependency on natural methods of nitrogen fixation. The process of making available reactive N for various purposes involves industrial nitrogen fixation from air as ammonia, which is then transformed into various products like fertilizer, synthetic fibers, plastics, animal feed, other chemicals and explosives. Thus, increase in demand of various N based products in the economy has greatly increased the artificial fixation of N in reactive form.

Artificial nitrogen fixation has greatly enhanced cropland productivity but it has negatively impacted ecosystem health, since the increased reactive N mobilization by anthropogenic activities have led to losses of reactive N to the environment [14]. There is increased concentration of reactive N in land, air and water which has negative impacts such as eutrophication, acidic soil, reduced biodiversity of plants, global warming etc. Studies have also quantified the effect of human consumption on reactive N losses and its negative effects on environment [20]. All of these studies indicate that the natural biogeochemical cycle of N has been greatly altered by human intervention. Due to increased mobilization of reactive N there is more of this component in the atmosphere and in various ecosystems which exceeds the natural rate of denitrification causing this nutrient cycle to be unbalanced. Effects of this imbalance include areas of high reactive N causing hypoxia, soil acidity, etc. Due to changes in soil and atmospheric N balance various microorganisms are possibly effected resulting in changes in natural N fixation by microorganisms in soil. However, this effect has not been validated due to inability to separate natural and anthropogenic emissions or fixation in natural systems such as soil. Such impacts of human activities on natural N biogeochemical cycle is yet not known and is currently under study [8]. However, the impact of excess reactive N presence in ecosystems can easily be seen as dead zones have developed, the soil properties have changed and global warming occurs because of N_2O emissions [12, 1, 15].

Even though high rate of formation of reactive N has negative consequences, yet it is not feasible to depend solely on natural circulation of N for satisfying the N fertilizer required for sustaining human needs [17]. It is thus, necessary to identify the potential ways of reducing the loss of reactive N to ecosystems and negative impact on ecosystems due to anthropogenic reactive N mobilization [10]. This requires the knowledge of reactive N mobilization, reactive N product end use, and reactive N losses from various human activities. Galloway et al. report that about 90% of NH3 produced by anthropogenic fixation is lost prior to human consumption [10]. This makes it extremely crucial to quantify the amount of reactive nitrogen that is being mobilized directly and indirectly by the use of economic goods and services. Even though loss of reactive N is the culprit that causes the negative impact, tracing the flow of reactive and non-reactive N to identify N use efficiency in anthropogenic systems will be helpful in devising ways of reducing such losses and meeting the objective of reducing anthropogenic impact on the N cycle.

S.3 Methodology for Calculation of V_{ph} in The Model

Each Vph vector mentioned in Table S.1 for Nitrogen components are calculated by allocation of total national flows to the peripheral sectors mentioned in Table S.1. The total national level flows are mentioned in Table S.1 along with the peripheral sectors to which it is allocated. The allocation is done similar to other EEIO approach where resource flows (Nr Mobilization and Nr Product categories) are mapped to sectors that extract or use it directly for production and Nr Emissions is mapped to peripheral sector that directly emits the Nr. The monetary size of these sectors are available from BEA. For the flows where physical basis of allocation such as land area was not available we have used monetary size of sectors as the allocation basis. This is the method adopted by several Input-Output researchers in scenario of lack of actual data. For some of the flows such as allocation of "Atmospheric Deposition" land area of the appropriate sectors was used to calculate each sector input of this flow. Since, atmospheric deposition is an aerial phenomenon; assumption of allocation based on land area was an appropriate way. For manure allocation we have revised allocation based on percentage of acres for each crop receiving manure based on USDA estimates [7]. Other flows are allocated based on monetary size of sector. This assumption is fairly valid for allocation of resources because a sector with higher monetary size may be using more resources. However, in ideal case we will need to use actual physical data which is not available as of now. The model will still perform well, to give insights into direct and indirect flows. A slight over or under estimation do not prove to be an issue because of the coarse scale of the model.

S.3.1 Choice of Ghosh Model

In this work, we treated the Nr flows that are used for supporting economic production as resources entering the economy and thus used the Ghosh model to calculate life cycle values for each sector. Since, the Ghosh model is only used to trace the linkages in economy and not implying a causal relationship between supply of resource and productivity of sectors; the use of Ghosh model here is free of the controversies in the literature. The fact that Ghosh matrix is only a different representation of same economic network as Leontief matrix it is valid to use it for IO-LCA calculations .

Table S.1: Components of Eco-LCA Nitrogen Life Cycle Inventory

	LCI Components	Source	Peripheral Sectors	Values (Tg-N)
Reactive N Mobilization	N fixed by soil micro-organisms	[19]	Farming, Cattle Ranching and Farming Forest Nurseries, forest products & timber tracts	1.15E-04
	Legume N Fixation (Soyabean)	[3]	Oilseed farming	3.30E+00
	Legume N Fixation (Alfalfa)	[3]	All other crop farming	2.10E+00
	Legume N Fixation (Other, peanuts, lentils etc	[3]	& Vegetable & melon farming	2.40E+00
	N input by atmospheric deposition	[6]	Farming, Cattle Ranching & Farming Forest Nurseries, forest products & timber tracts	6.90E+00
	Industrial N fixation as Ammonia	[4]	Nitrogenous Fertilizer Manu.	1.03E+01
Reactive N End Use	N used as farm fertilizer	[6]	All farming	1.02E+01
	N used as non-farm fertilizer	[6]	Residential Unit, Commercial & institutional buildings	3.24E-01
	N used as Livestock Manure	[6]	Farming; Commercial & institutional buildings	5.84E+00
	N in Plastics & Synthetics Manu.	[5]	Plastics material & resin manu. ; Synthetic rubber manu.; Noncellulosic organic fiber manu.	7.26E-01
	N in Explosives Manu.	[5]	Explosives Manu.	1.48E+00
	N in Animal Feed and other chemical manu.	[5]	Other basic inorganic chemical manu.	1.13E-01
	N consumed by human as Harvested Crop	[16]	Agricultural Food Processing	1.30E+00
	N consumed by human as Animal Food(Meat)	[16]	Dairy and meat processing	9.00E-01

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Table S.1 – continued from previous page

	LCI Components	Source	Peripheral Sector	Values (Tg-N)
Reactive N Loss to Air, Water and Land	N_2O emissions from fuel use	[9]	All sectors	4.80E-02
	NO_x emissions from fuel use	[2]	Respective Sectors	5.32E+00
	N_2O emissions from manure management	[9]	Cattle ranching & farming; Poultry & egg production; Animal prod, except cattle & poultry & eggs	3.64E-02
	N_2O direct emission from Agricultural Soil Management-cropland & grassland	[9]	All farming & Cattle, ranching & farming sectors	3.51E-01
	N_2O indirect emission from Agricultural Soil Management-cropland,grassland, forest & settlements	[9]	All farming; Forestry & Residential Settlement	9.22E-02
	N_2O field burning of agricultural residues	[9]	Oilseed, Grain & All other crop farming	1.08E-03
	NO_x field burning of agricultural residues	[9]	Oilseed, Grain & All other crop farming	1.53E-02
	N_2O forest fire emissions	[9]	Forest nurseries, forest products & timber tracts	2.11E-02
	N_2O direct emissions from soil management- forest land remaining forest land and land converted to forestland	[9]	Forest nurseries, forest products & timber tracts.	6.40E-04
	N_2O direct emissions from soil management-emissions from settlement soils	[9]	Urban Land	2.56E-03
	N_2O emissions from nitric acid production	[9]	Nitrogenous Fertilizer Manu.	3.78E-02
	N_2O emissions from adipic acid production	[9]	Plastics material & resin manu.	1.09E-02
	N_2O emissions from domestic water water treatment	[9]	Water, sewage & other systems	9.60E-03
	N_2O emissions from composting	[9]	Waste management & remediation services	3.20E-03
	N loading to water (Ammonia N)	[6]	All farming, Cattle ranching & farming & water sewage & other systems	2.44E-02
	N loading to water (Inorganic N as Nitrite and Nitrate)	[6]	All farming , Cattle ranching & farming & water sewage & other systems	7.41E-01
	N loading to water (Organic N)	[6]	All farming, Cattle ranching & farming, water sewage & other systems	1.64E-01
	N sewage sludge applied to agricultural land	Calc.	All farming , Cattle ranching & farming	1.44E-01

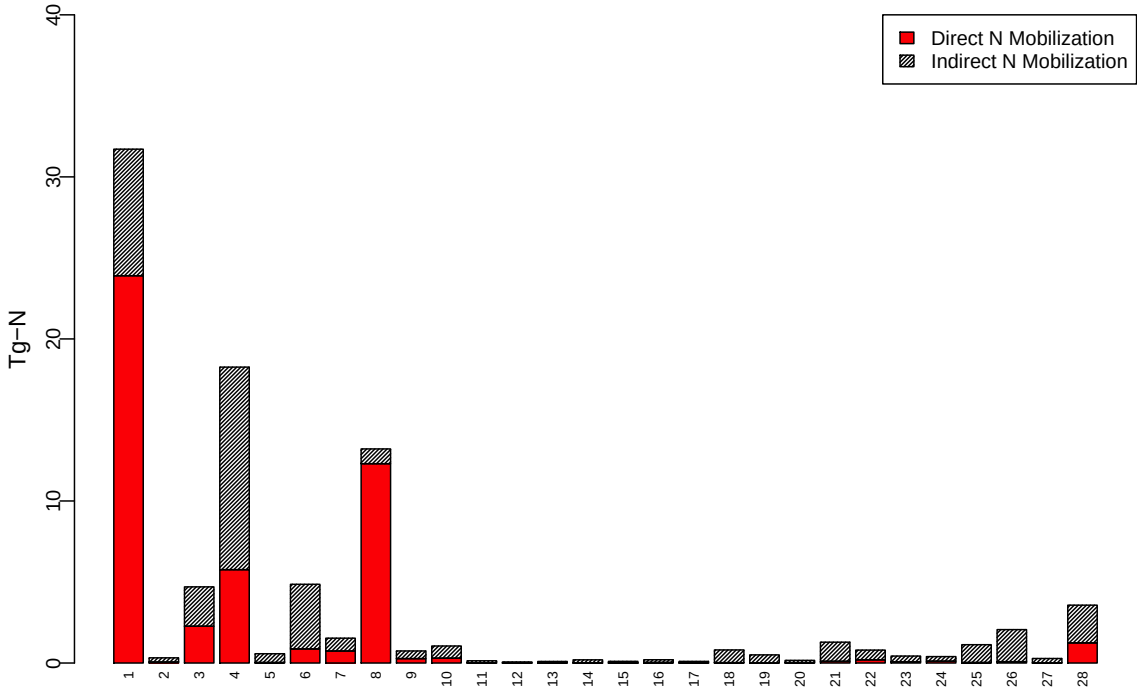

Figure S.1: Reactive N Profile for 2002 Economic Sectors. Legend for x-axis. 1: Agriculture,Livestock, Forestry & Fisheries 2: Mining & Utilities 3 : Construction 4: Food,Beverage & Tobacco 5: Textiles, Apparel & Leather 6: Wood,Paper & Printing 7: Petroleum & Basic Chemical 8: Resin, Rubber, Artificial Fibers, Agri Chem & Pharma 9: Paint, Adhesives, Cleaning & Other Chem 10: Plastics, Rubber & Non-metallic mineral prod 11: Ferrous & non-ferrous metal prod. 12: Cutlery, Handtools, Struc. & Metal Containers 13: Other metal hardware & ordnance manu. 14: Machinery & Engines 15: Computers, Audio-Video & Comm. Equip 16: Semiconductors, Elec Equip & Media Reproduction 17: Lighting, Electrical Compo. & Batteries 18: Vehicles & Other Transportation Equip 19: Furniture, Medical, Equip & Supplies 20: Other Misc. Manu. 21: Trade, Transportation & Commu. media 22: Finance, Insu, Real-Estate, Rental & Leasing 23: Professional & Technical Services 24: Management, Admin & Waste Services 25: Education & Health Care Services 26: Arts, Entertainment, Hotels & Food Services 27: Other services except Public Administration 28: Government & Special Services

S.4 Direct and Indirect Flows

Figures S.1, S.2, and S.3 show the direct and indirect flows for the aggregated sectors and correspond to 2, 3, and 4 in the main paper.

The remaining figures focus on the top five aggregated sectors for each profile and show the details of sectors that constitute each aggregate sector.

N mobilization: "Agriculture, Livestock, Forestry and Fisheries (1)," "Food,Beverage & Tobacco (4)," "Resin, Rubber, Artificial Fibers, Agri Chem & Pharma (8)," "Wood,Paper & Printing (6)," "Construction (3)."

N in products: "Agriculture, Livestock, Forestry and Fisheries (1)," "Food, Beverage and Tobacco (4)," "Construction (3)," "Paint, Adhesives, Cleaning & other Chemicals (9)," and "Resin, Rubber, Artificial fibers, Agri. Chemicals & Pharma (8)."

N emissions: "Agriculture, Livestock, Forestry and Fisheries (1)," "Mining and Utilities (2)," "Food, Beverage and Tobacco (4)," "Trade, Transportation & Commu. media (21)," "Government & Special Services (28)."

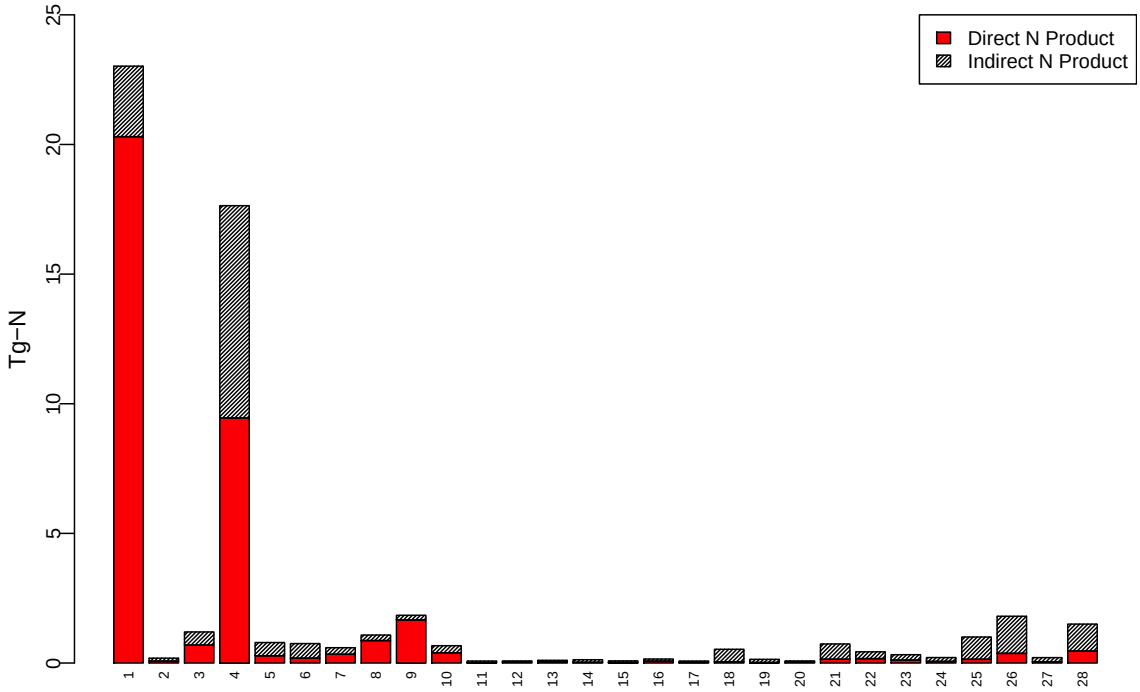

Figure S.2: Product N Profile for 2002 Economic Sectors. Legend for x-axis is in Figure S.1

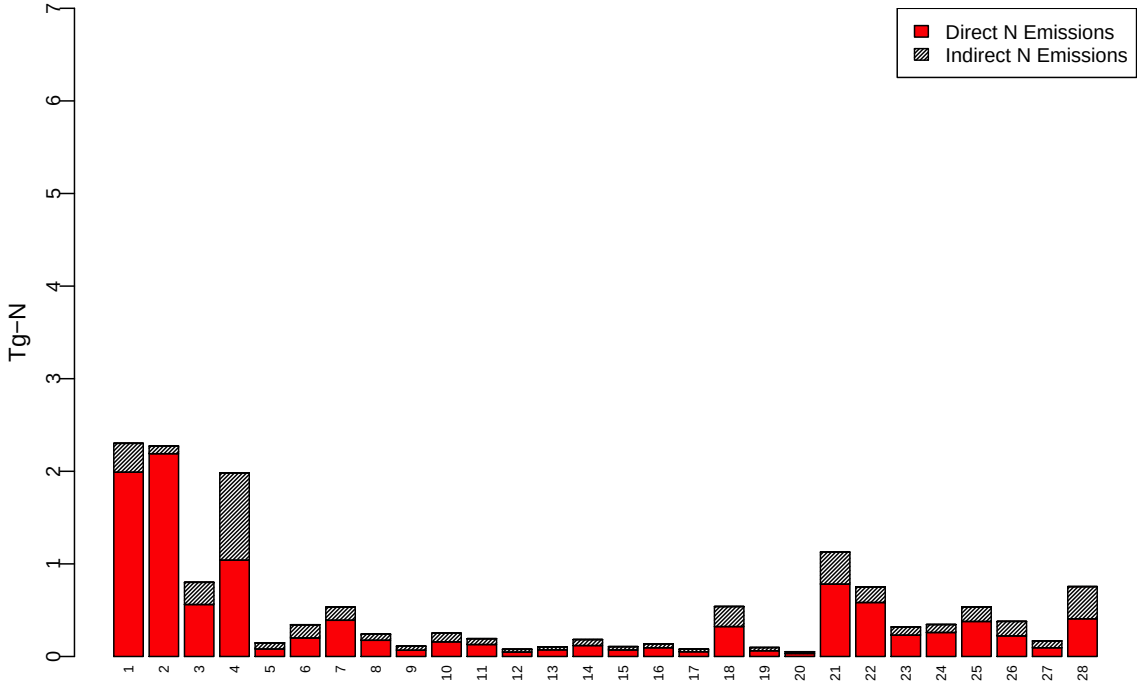

Figure S.3: N emissions Profile for 2002 Economic Sectors. Legend for x-axis is in Figure S.1

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors

Table S.2: Aggregation scheme for 2002 U.S. economy

Number	NAICS	Sector Name	Aggregated Sectors
1	1111A0	Oilseed Farming	Agriculture, Livestock, Forestry and Fisheries (1)
2	1111B0	Grain Farming	
3	111200	Vegetable and Melon Farming	
4	111335	Tree Nut Farming	
5	1113A0	Fruit Farming	
6	111400	Greenhouse, nursery and floriculture production	
7	111910	Tobacco farming	
8	111920	Cotton farming	
9	1119A0	Sugarcane and sugar beet farming	
10	1119B0	All other crop farming	
11	112120	Dairy cattle and milk production	
12	1121A0	Cattle ranching and farming	
13	112300	Poultry and egg production	
14	112A00	Animal production (other)	
15	113300	Logging	
16	113A00	Forest nurseries, forest productions and timber tracts	
17	114100	Fishing	
18	114200	Hunting and Trapping	
19	115000	Support activities for agriculture and forestry	
20	211000	Oil and gas extraction	Mining and Utilities (2)
21	212100	Coal mining	
22	212210	Iron Ore Mining	
23	212230	Copper, Nickel, Lead and Zinc Mining	
24	2122A0	Gold, Silver and other metal ore mining	
25	212310	Stone mining and quarrying	
26	212320	Sand, gravel, clay and ceramic and refractory minerals mining	
27	212390	Other nonmetallic mineral mining	
28	213111	Drilling oil and gas wells	
29	213112	Support activities for oil and gas operations	
30	21311A	Support activities for other mining	
31	221100	Electric power generation, transmission and distribution	
32	221200	Natural gas distribution	
33	221300	Water, Sewage and other systems	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
34	230101	Nonresidential commercial and health care structures	Construction (3)
35	230102	Nonresidential manufacturing structures	
36	230103	Other nonresidential structures	
37	230201	Residential permanent site single and multi-family structures	
38	230202	Other residential structures	
39	230301	Nonresidential maintenance and repair	
40	230302	Residential maintenance and repair	
41	311111	Dog and cat food manufacturing	Food, Beverage and Tobacco (4)
42	311119	Other animal food manufacturing	
43	311210	Flour milling and malt manufacturing	
44	311221	Wet corn milling	
45	311225	Fats and oils refining and blending	
46	31122A	Soybean and other oilseed processing	
47	311230	Breakfast cereal manufacturing	
48	311313	Beet sugar manufacturing	
49	31131A	Sugar cane mills and refining	
50	311320	Chocolate and confectionery manufacturing from cacao beans	
51	311330	Confectionery manufacturing from purchased chocolate	
52	311340	Nonchocolate confectionery manufacturing	
53	311410	Frozen food manufacturing	
54	311420	Fruit and vegetable canning, pickling and drying	
55	311513	Cheese manufacturing	
56	311514	Dry, condensed and evaporated dairy product manufacturing	
57	31151A	Fluid milk and butter manufacturing	
58	311520	Ice cream and frozen dessert manufacturing	
59	311615	Poultry processing	
60	31161A	Animal (except poultry) slaughtering, rendering and processing	
61	311700	Seafood product preparation and packaging	
62	311810	Bread and bakery product manufacturing	
63	311820	Cookie, cracker and pasta manufacturing	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
64	311830	Tortilla manufacturing	
65	311910	Snack food manufacturing	
66	311920	Coffee and tea manufacturing	
67	311930	Flavoring syrup and concentrate manufacturing	
68	311940	Seasoning and dressing manufacturing	
69	311990	All other food manufacturing	
70	312110	Soft drink and ice manufacturing	
71	312120	Breweries	
72	312130	Wineries	
73	312140	Distilleries	
74	3122A0	Tobacco product manufacturing	
75	313100	Fiber, yarn and thread mills	Textiles, Apparel and Leather (5)
76	313210	Broadwoven fabric mills	
77	313220	Narrow fabric mills and machine embroidery	
78	313230	Non-woven fabric mills	
79	313240	Knit fabric mills	
80	313310	Textile and fabric finishing mills	
81	313320	Fabric coating mills	
82	314110	Carpet and rug mills	
83	314120	Curtain and linen mills	
84	314910	Textile bag and canvas mills	
85	314990	All other textile product mills	
86	315100	Apparel knitting mills	
87	315210	Cut and sew apparel contractors	
88	315220	Men's and boys' cut and sew apparel manufacturing	
89	315230	Women's and girls' cut and sew apparel manufacturing	
90	315290	Other cut and sew apparel manufacturing	
91	315900	Apparel accessories and other apparel manufacturing	
92	316100	Leather and hide tanning and finishing	
93	316200	Footwear manufacturing	
94	316900	Other leather and allied product manufacturing	
95	321100	Sawmills and wood preservation	Wood Paper and Printing (6)
96	321219	Reconstituted wood product manufacturing	
97	32121A	Veneer and plywood manufacturing	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
98	32121B	Engineered wood member and truss manufacturing	
99	321910	Wood windows and doors and millwork	
100	321920	Wood container and pallet manufacturing	
101	321991	Manufactured home (mobile home) manufacturing	
102	321992	Prefabricated wood building manufacturing	
103	321999	All other miscellaneous wood product manufacturing	
104	322110	Pulp mills	
105	322120	Paper Mills	
106	322130	Paperboard mills	
107	322210	Paperboard container manufacturing	
108	32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	
109	32222B	All other paper back and coated and treated paper manufacturing	
110	322230	Stationery product manufacturing	
111	322291	Sanitary paper product manufacturing	
112	322299	All other converted paper product manufacturing	
113	323110	Printing	
114	323120	Support activities for printing	
115	324110	Petroleum refineries	Petroleum and Basic Chemical (7)
116	324121	Asphalt paving mixture and block manufacturing	
117	324122	Asphalt shingle and coating materials manufacturing	
118	324191	Petroleum lubricating oil and grease manufacturing	
119	324199	All other petroleum and coal products manufacturing	
120	325110	Petrochemical manufacturing	
121	325120	Industrial gas manufacturing	
122	325130	Synthetic dye and pigment manufacturing	
123	325181	Alkalies and chlorine manufacturing	
124	325182	Carbon black manufacturing	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
125	325188	All other basic inorganic chemical manufacturing	
126	325190	Other basic organic chemical manufacturing	
127	325211	Plastics material and resin manufacturing	Resin, Rubber, Artificial Fibers, Agricultural Chemicals and Pharma (8)
128	325212	Synthetic rubber manufacturing	
129	325220	Artificial and synthetic fibers and filaments manufacturing	
130	325310	Fertilizer manufacturing	
131	325320	Pesticide and other agricultural chemical manufacturing	
132	325411	Medicinal and botanical manufacturing	
133	325412	Pharmaceutical preparation manufacturing	
134	325413	In-vitro diagnostic substance manufacturing	
135	325414	Biological product (except diagnostic) manufacturing	
136	325510	Paint and coating manufacturing	Paint, Adhesives, Cleaning and Other Chemicals (9)
137	325520	Adhesive manufacturing	
138	325610	Soap and cleaning compound manufacturing	
139	325620	Toilet preparation manufacturing	
140	325910	Printing ink manufacturing	
141	3259A0	All other chemical product and preparation manufacturing	
142	326110	Plastics packaging materials and unlaminated film and sheet manufacturing	Plastics, Rubber and Non-metallic mineral products (10)
143	326121	Unlaminated plastics profile shape manufacturing	
144	326122	Plastic pipe and pipe fitting manufacturing	
145	326130	Laminated plastics plate, sheet (except packaging)and shape manufacturing	
146	326140	Polystyrene foam product manufacturing	
147	326150	Urethane and other foam product (except polystyrene) manufacturing	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
148	326160	Plastics bottle manufacturing	
149	32619A	Other plastics product manufacturing	
150	326210	Tire manufacturing	
151	326220	Rubber and plastics hoses and belting manufacturing	
152	326290	Other rubber product manufacturing	
153	32711A	Pottery, ceramics and plumbing fixture manufacturing	
154	32712A	Brick, tile and other structural clay product manufacturing	
155	32712B	Clay and nonclay refractory manufacturing	
156	327211	Flat glass manufacturing	
157	327212	Other pressed and blown glass and glassware manufacturing	
158	327213	Glass container manufacturing	
159	327215	Glass product manufacturing made of purchased glass	
160	327310	Cement manufacturing	
161	327320	Ready-mix concrete manufacturing	
162	327330	Concrete pipe, brick and block manufacturing	
163	327390	Other concrete product manufacturing	
164	3274A0	Lime and gypsum product manufacturing	
165	327910	Abrasive product manufacturing	
166	327991	Cut stone and stone product manufacturing	
167	327992	Ground or treated mineral and earth manufacturing	
168	327993	Mineral wool manufacturing	
169	327999	Miscellaneous nonmetallic mineral products	
170	331110	Iron and steel mills and ferroalloy manufacturing	Ferrous and non-ferrous metal production (11)
171	331200	Steel product manufacturing from purchased steel	
172	331314	Secondary smelting and alloying of aluminum	
173	33131A	Alumina refining and primary aluminum production	
174	33131B	Aluminum product manufacturing from purchased aluminum	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
175	331411	Primary smelting and refining of copper	
176	331419	Primary smelting and refining of nonferrous metal (except copper and aluminum)	
177	331420	Copper rolling, drawing , extruding and alloying	
178	331490	Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	
179	331510	Ferrous metal foundries	
180	331520	Nonferrous metal foundries	
181	332114	Custom roll forming	
182	33211A	All other forging, stamping and sintering	
183	33211B	Crown and closure manufacturing and metal stamping	
184	33221A	Cutlery, untensil, pot and pan manufacturing	Cutlery, Handtools , Structural and Metal Containers (12)
185	33221B	Handtool manufacturing	
186	332310	Plate work and fabricated structural product manufacturing	
187	332320	Ornamental and architectural metal producs manufacturing	
188	332410	Power boiler and heat exchanger manufacturing	
189	332420	Metal tank (heavy gauge) manufacturing	
190	332430	Metal can, box and other metal container (light gauge) manufacturing	
191	332500	Hardware manufacturing	Other metal hardware and ordnance manufacturing (13)
192	332600	Spring and wire product manufacturing	
193	332710	Machine shops	
194	332720	Turned product and screw, nut and bolt manufacturing	
195	332800	Coating, engraving, heat treating and allied activities	
196	332913	Plumbing fixture fitting and trim manufacturing	
197	33291A	Valve and fittings other than plumbing	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
198	332991	Ball and roller bearing manufacturing	
199	332996	Fabricated pipe and pipe fitting manufacturing	
200	33299A	Ammunition manufacturing	
201	33299B	Arms, ordnance and accessories manufacturing	
202	33299C	Other fabricated metal manufacturing	
203	333111	Farm machinery and equipment manufacturing	Machinery and Engines (14)
204	333112	Lawn and garden equipment manufacturing	
205	333120	Construction machinery manufacturing	
206	333130	Mining and oil and gas field machinery manufacturing	
207	333220	Plastics and rubber industry machinery manufacturing	
208	333295	Semiconductor machinery manufacturing	
209	33329A	Other industrial machinery manufacturing	
210	333314	Optical instrument and lens manufacturing	
211	333315	Photographic and photocopying equipment manufacturing	
212	333319	Other commercial and service industry machinery manufacturing	
213	33331A	Vending, commercial, industrial and office machinery manufacturing	
214	333414	Heating equipment except warm air furnaces	
215	333415	Air conditioning, refrigeration and warm air heating equipment manufacturing	
216	33341A	Air purification and ventilation equipment manufacturing	
217	333511	Industrial mold manufacturing	
218	333514	Special tool,die, jig and fixture manufacturing	
219	333515	Cutting tool and machine tool accessory manufacturing	
220	33351A	Metal cutting and forming machine tool manufacturing	
221	33351B	Rolling mill and other metalworking machinery manufacturing	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
222	333611	Turbine and turbine generator set units manufacturing	
223	333612	Speed changer, industrial high-speed drive and gear manufacturing	
224	333613	Mechanical power transmission equipment manufacturing	
225	333618	Other engine equipment manufacturing	
226	333911	Pump and pumping equipment manufacturing	
227	333912	Air and gas compressor manufacturing	
228	333920	Material handling equipment manufacturing	
229	333991	Power-driven hand-tool manufacturing	
230	333993	Packaging machinery manufacturing	
231	333994	Industrial process furnace and oven manufacturing	
232	33399A	Other general purpose machinery manufacturing	
233	33399B	Fluid power process machinery	
234	334111	Electronic computer manufacturing	Computers, Audio-Video and Communications Equipments (15)
235	334112	Computer storage device manufacturing	
236	33411A	Computer terminals and other computer peripheral equipment manufacturing	
237	334210	Telephone apparatus manufacturing	
238	334220	Broadcast and wireless communications equipment	
239	334290	Other communications equipment manufacturing	
240	334300	Audio and video equipment manufacturing	
241	334411	Electron tube manufacturing	
242	334412	Bare printed circuit board manufacturing	
243	334413	Semiconductor and related device manufacturing	Semiconductors, Electronic Equipments and Media Reproduction (16)
244	334417	Electronic connector manufacturing	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
245	334418	Printed circuit assembly (electronic assembly) manufacturing	
246	334419	Other electronic component manufacturing	
247	33441A	Electronic capacitor, resistor, coil, transformer and other inductor manufacturing	
248	334510	Electromedical and electrotherapeutic apparatus manufacturing	
249	334511	Search, detection and navigation instruments manufacturing	
250	334512	Automatic environmental control manufacturing	
251	334513	Industrial process variable instruments manufacturing	
252	334514	Totalizing fluid meters and counting devices manufacturing	
253	334515	Electricity and signal testing instruments manufacturing	
254	334516	Analytical laboratory instrument manufacturing	
255	334517	Irradiation apparatus manufacturing	
256	33451A	Watch, clock and other measuring and controlling device manufacturing	
257	334613	Magnetic and optical recording media manufacturing	
258	33461A	Software, audio and video media reproducing	
259	335110	Electric lamp bulb and part manufacturing	Lighting, Electrical Components and Batteries (17)
260	335120	Lighting fixture manufacturing	
261	335210	Small electrical appliance manufacturing	
262	335221	Household cooking appliance manufacturing	
263	335222	Household refrigerator and home freezer manufacturing	
264	335224	Household laundry equipment manufacturing	
265	335228	Other major household appliance manufacturing	
266	335311	Power, distribution and specialty transformer manufacturing	
267	335312	Motor and generator manufacturing	

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Number	NAICS	Sector Name	Aggregated Sectors
268	335313	Switchgear and switchboard apparatus manufacturing	
269	335314	Relay and industrial control manufacturing	
270	335911	Storage battery manufacturing	
271	335912	Primary battery manufacturing	
272	335920	Communication and energy wire and cable manufacturing	
273	335930	Wiring device manufacturing	
274	335991	Carbon and graphite product manufacturing	
275	335999	All other miscellaneous electrical equipment and component manufacturing	
276	336111	Automobile manufacturing	Vehicles and other transportation equipment (18)
277	336112	Light truck and utility vehicle manufacturing	
278	336120	Heavy duty truck manufacturing	
279	336211	Motor vehicle body manufacturing	
280	336212	Truck trailer manufacturing	
281	336213	Motor home manufacturing	
282	336214	Travel trailer and camper manufacturing	
283	336300	Motor vehicle parts manufacturing	
284	336411	Aircraft manufacturing	
285	336412	Aircraft engine and engine parts manufacturing	
286	336413	Other aircraft parts and auxiliary equipment manufacturing	
287	336414	Guided missile and space vehicle manufacturing	
288	33641A	Propulsion units and parts for space vehicles and guided missiles	
289	336500	Railroad rolling stock manufacturing	
290	336611	Ship building and repairing	
291	336612	Boat building	
292	336991	Motorcycle, bicycle and parts manufacturing	
293	336992	Military armored vehicle, tank and tank component manufacturing	
294	336999	All other transportation equipment manufacturing	
295	337110	Wood kitchen cabinet and countertop manufacturing	Furniture, Medical Equipment and supplies(19)

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
296	337121	Upholstered household furniture manufacturing	
297	337122	Nonupholstered wood household furniture manufacturing	
298	337127	Institutional furniture manufacturing	
299	33712A	Metal and other household furniture (except wood) manufacturing	
300	337212	Office furniture and custom architectural woodwork and millwork manufacturing	
301	337215	Showcase, partition, shelving and locker manufacturing	
302	33721A	Wood television, radio and sewing machine cabinet manufacturing	
303	337910	Mattress manufacturing	
304	337920	Blind and shade manufacturing	
305	339111	Laboratory apparatus and furniture manufacturing	
306	339112	Surgical and medical instrument manufacturing	
307	339113	Surgical appliance and supplies manufacturing	
308	339114	Dental equipment and supplies manufacturing	
309	339115	Ophthalmic goods manufacturing	
310	339116	Dental laboratories	
311	339910	Jewelry and silverware manufacturing	Other miscellaneous manufacturing(20)
312	339920	Sporting and athletic goods manufacturing	
313	339930	Doll, toy and game manufacturing	
314	339940	Office supplies (except paper) manufacturing	
315	339950	Sign manufacturing	
316	339991	Gasket, packing and sealing device manufacturing	
317	339992	Musical instrument manufacturing	
318	339994	Broom, brush and mop manufacturing	
319	33999A	All other miscellaneous manufacturing	
320	420000	Wholesale trade	Trade, Transportation and communications media(21)
321	481000	Air transportation	
322	482000	Rail transportation	
323	483000	Water transportation	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
324	484000	Truck transportation	
325	485000	Transit and ground passenger transportation	
326	486000	Pipeline transportation	
327	48A000	Scenic, sightseeing transportation & support activities for transp.	
328	491000	Postal service	
329	492000	Couriers and messengers	
330	493000	Warehousing and storage	
331	4A0000	Retail trade	
332	511110	Newspaper publishers	
333	511120	Periodical publishers	
334	511130	Book publishers	
335	5111A0	Directory, mailing list and other publishers	
336	511200	Software publishers	
337	512100	Motion picture and video industries	
338	512200	Sound recording industries	
339	515100	Radio and television broadcasting	
340	515200	Cable and other subscription programming	
341	516110	Internet publishing and broadcasting	
342	517000	Telecommunications	
343	518100	Internet service providers and web search portals	
344	518200	Data processing, hosting and related services	
345	519100	Other information services	
346	522A00	Nondepository credit intermediation and related activities	Finance, Insurance, real Estate, Rental and Leasing (22)
347	523000	Securities, commodity contracts, investments and related activities	
348	524100	Insurance carriers	
349	524200	Insurance agencies,brokerages and related activities	
350	525000	Funds,trusts and other financial vehicles	
351	52A000	Monetary authorities and depository credit intermediation	
352	531000	Real estate	
353	532100	Automotive equipment rental and leasing	
354	532230	Video tape and disc rental	
355	532400	Commercial and industrial machinery and equipment rental and leasing	

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Number	NAICS	Sector Name	Aggregated Sectors
356	532A00	General and consumer goods rental except video tapes and discs	
357	533000	Lessors of non-financial intangible assets	
358	541100	Legal services	Professional & Technical Services (23)
359	541200	Accounting, tax preparation, bookkeeping and payroll services	
360	541300	Architectural,engineering and related services	
361	541400	Specialized design services	
362	541511	Custom computer programming services	
363	541512	Computer systems design services	
364	54151A	Other computer related services, including facilities management	
365	541610	Management, scientific and technical consulting services	
366	5416A0	Environmental and other technical consulting services	
367	541700	Scientific research and development services	
368	541800	Advertising and related services	
369	541920	Photographic services	
370	541940	Veterinary services	
371	5419A0	All other miscellaneous professional, scientific and technical services	
372	550000	Management of companies and enterprises	Management, Administrative and waste services (24)
373	561100	Office administrative services	
374	561200	Facilities support services	
375	561300	Employment services	
376	561400	Business support services	
377	561500	Travel arrangement and reservation services	
378	561600	Investigation and security services	
379	561700	Services to buildings and dwellings	
380	561900	Other support services	
381	562000	Waste management and remediation services	
382	611100	Elementary and secondary schools	Education and Health Care Services (25)
383	611A00	Junior colleges, colleges,universities and professional schools	

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Table S.2 – continued from previous page

Number	NAICS	Sector Name	Aggregated Sectors
384	611B00	Other educational services	
385	621600	Home health care services	
386	621A00	Offices of physicians, dentists and other health practitioners	
387	621B00	Medical, diagnostic labs, outpatient and other ambulatory care services	
388	622000	Hospitals	
389	623000	Nursing and residential care facilities	
390	624200	Community food, housing and other relief services including rehabilitation services	
391	624400	Child day care services	
392	624A00	Individual and family services	
393	711100	Performing arts companies	Arts, Entertainment, Hotels and Food Services (26)
394	711200	Spectator sports	
395	711500	Independent artists, writers and performers	
396	711A00	Promoters of performing arts and sports and agents for public figures	
397	712000	Museums, historical sites, zoos and parks	
398	713940	Fitness and recreational sports centers	
399	713950	Bowling centers	
400	713A00	Amusement parks, arcades and gambling industries	
401	713B00	Other amusement and recreation industries	
402	7211A0	Hotels and motels including casino hotels	
403	721A00	Other accommodations	
404	722000	Food services and drinking places	
405	811192	Car washes	Other services except Public Administration (27)
406	8111A0	Automotive repair and maintenance except car washes	
407	811200	Electronic and precision equipment repair and maintenance	
408	811300	Commercial and industrial machinery and equipment repair and maintenance	
409	811400	Personal and household goods repair and maintenance	
410	812100	Personal care services	

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Number	NAICS	Sector Name	Aggregated Sectors
411	812200	Death care services	
412	812300	Dry-cleaning and laundry services	
413	812900	Other personal services	
414	813100	Religious organizations	
415	813A00	Grantmaking, giving and social advocacy organizations	
416	813B00	Civic, social, professional, and similar organizations	
417	814000	Private households	
418	S00101	Federal electric utilities	Government & Special Services (28)
419	S00102	Other Federal Government enterprises	
420	S00201	State and local government passenger transit	
421	S00202	State and local government electric utilities	
422	S00203	Other state and local government enterprises	
423	S00500	General Federal defense government services	
424	S00600	General Federal nondefense government services	
425	S00700	General state and local government services	
426	S00800	Owner-occupied dwellings	

Figure S.19 shows comparison among three components of the Nitrogen inventory.

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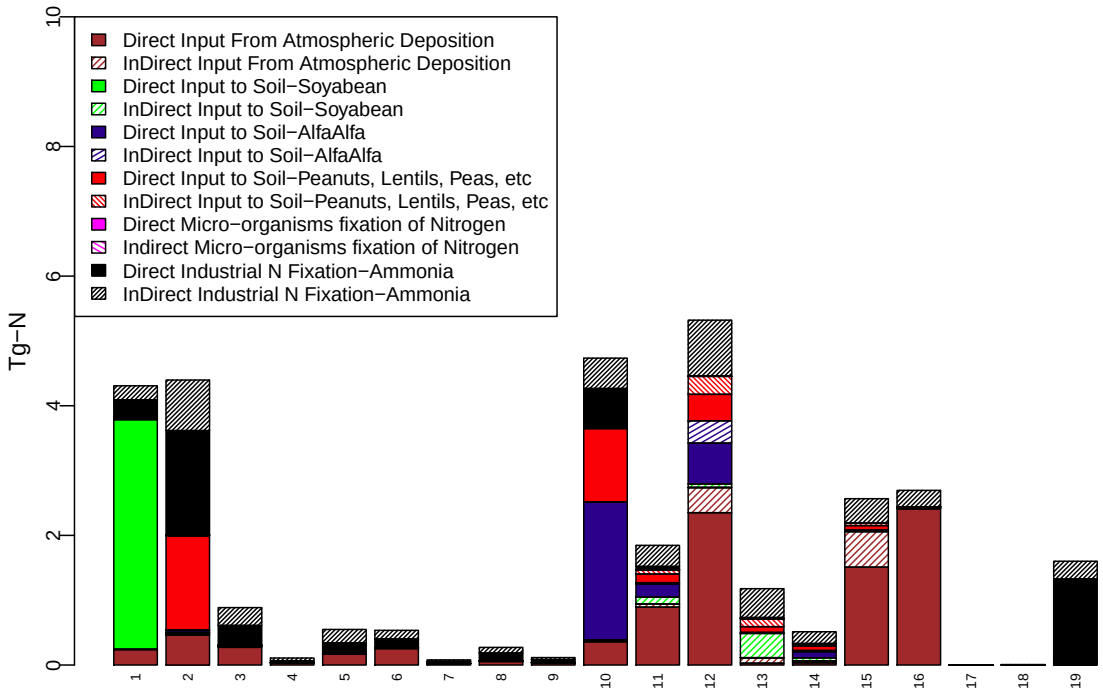

Figure S.4: N mobilization for aggregate sector "Agriculture, Livestock, Forestry and Fisheries (1)." Legend for x-axis. 1: Oilseed farming 2: Grain farming 3: Vegetable and Melon farming 4: Tree Nut farming 5: Fruit farming 6: Greenhouse, nursery and floriculture production 7: Tobacco farming 8: Cotton farming 9: Sugarcane and sugar beet farming 10: All other crop farming 11: Dairy cattle and milk production 12: Cattle ranching and farming 13: Poultry and egg production 14: Animal production (other) 15: Logging 16: Forest nurseries, forest productions and timber tracts 17: Fishing 18: Hunting and trapping 19: Support activities for agriculture and forestry

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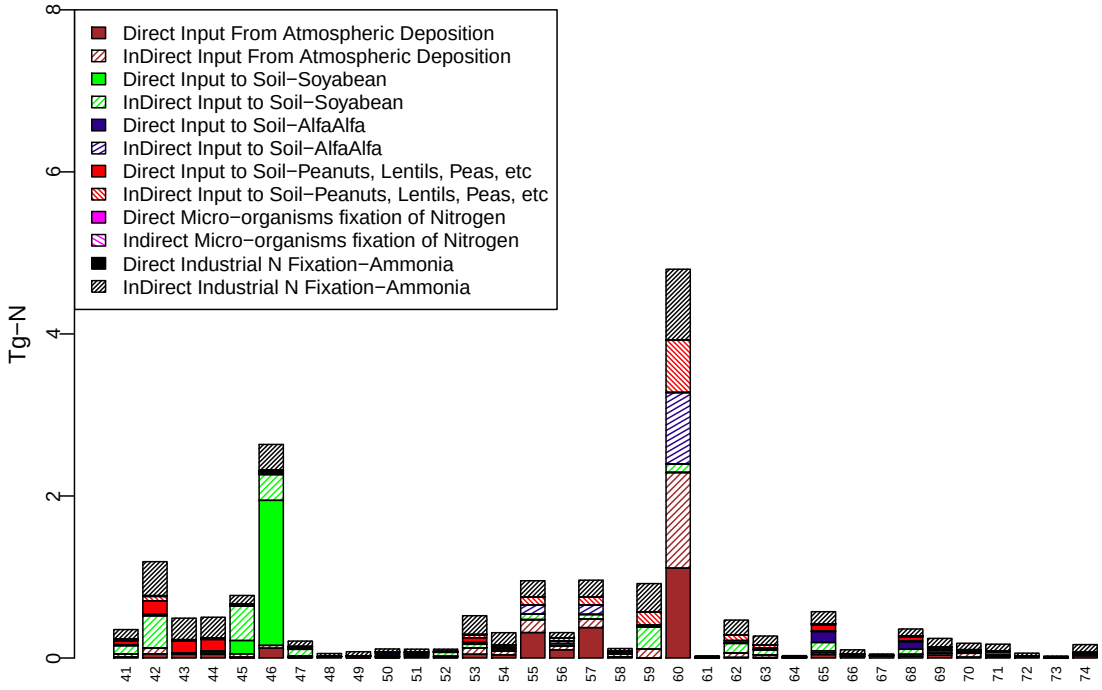

Figure S.5: N mobilization for aggregate sector "Food,Beverage & Tobacco (4)." Legend for x-axis. Legend for x-axis is in Table S.2.

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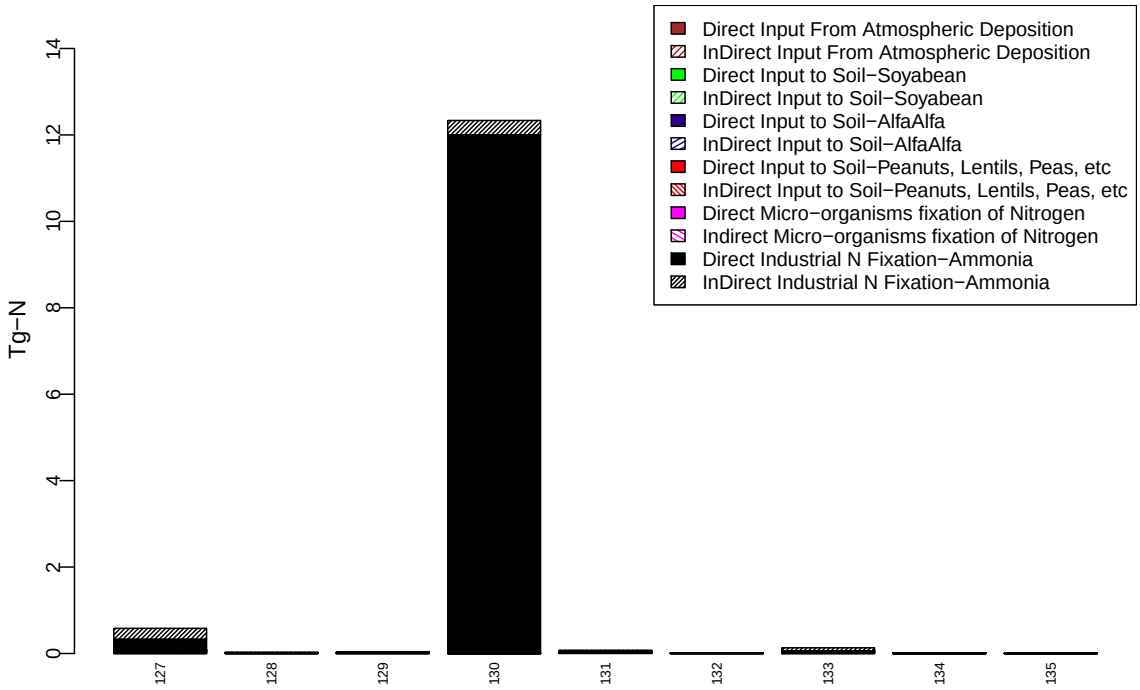

Figure S.6: N mobilization for aggregate sector "Resin, Rubber, Artificial Fibers, Agri Chem & Pharma (8)." Legend for x-axis is in Table S.2.

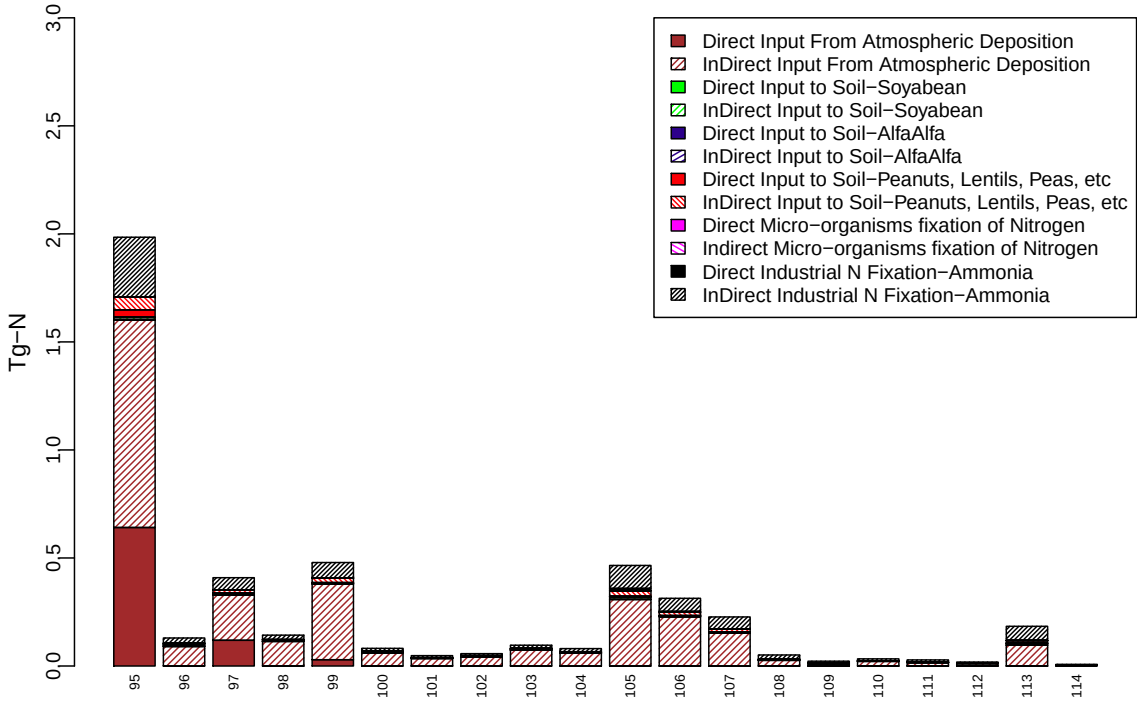

Figure S.7: N mobilization for aggregate sector "Wood,Paper & Printing (6)." Legend for x-axis is in Table S.2.

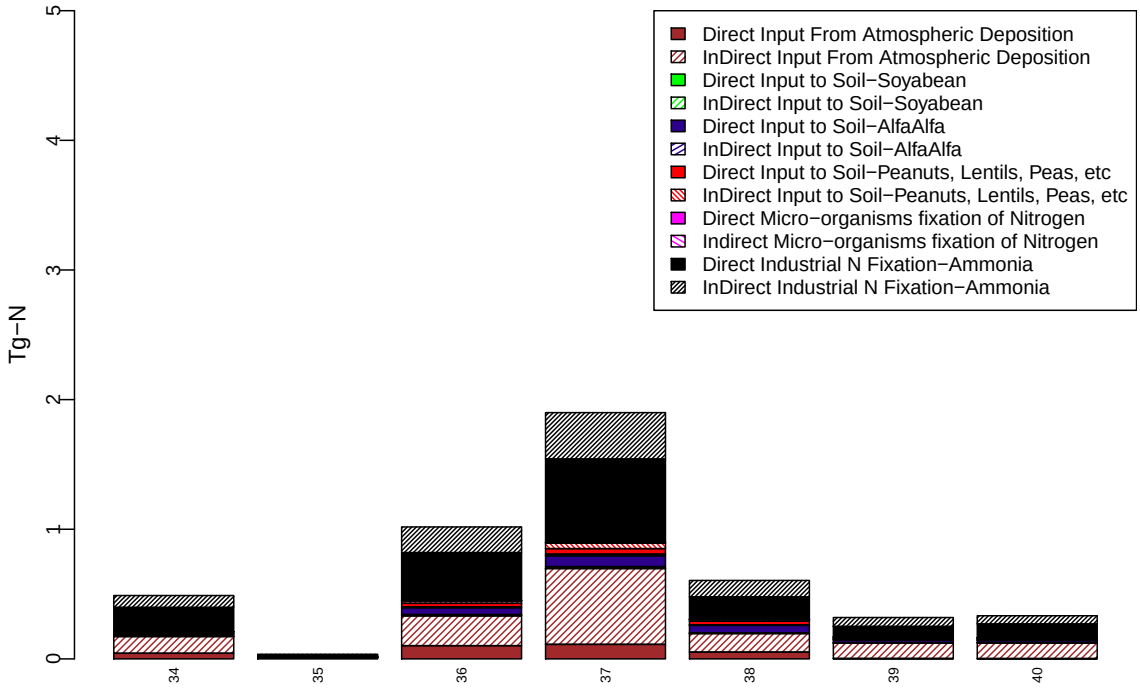

Figure S.8: N mobilization for aggregate sector "Construction (3)." Legend for x-axis is in Table S.2.

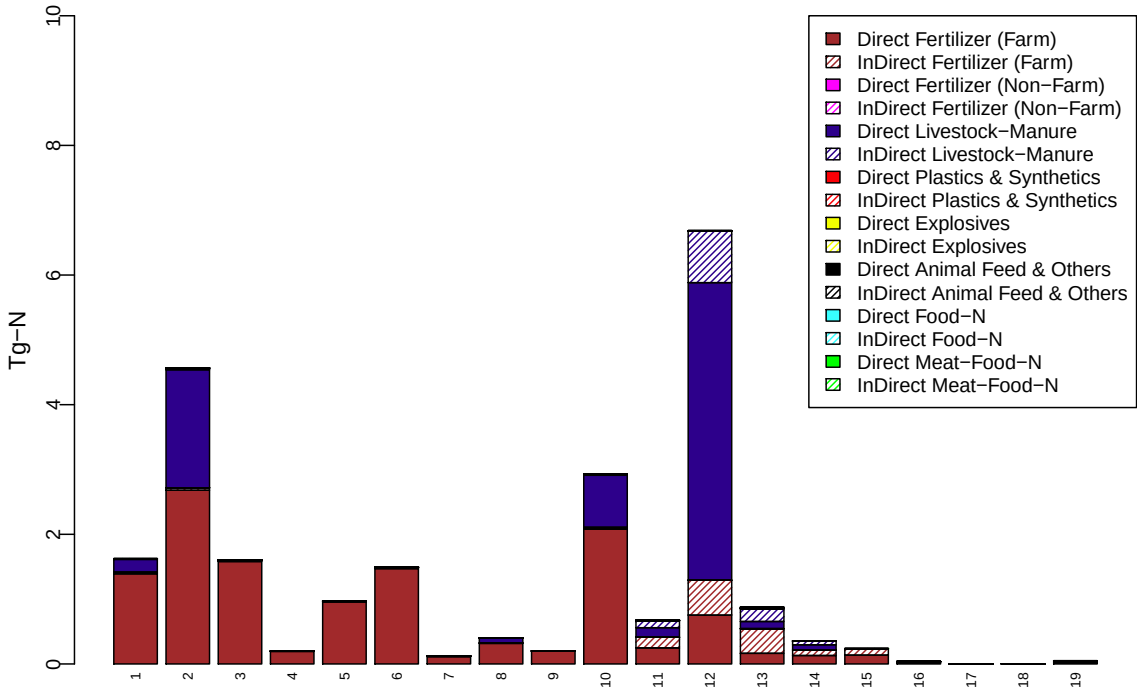

Figure S.9: N in products for aggregate sector "Agriculture, Livestock, Forestry and Fisheries (1)." Legend for x-axis is in Table S.2.

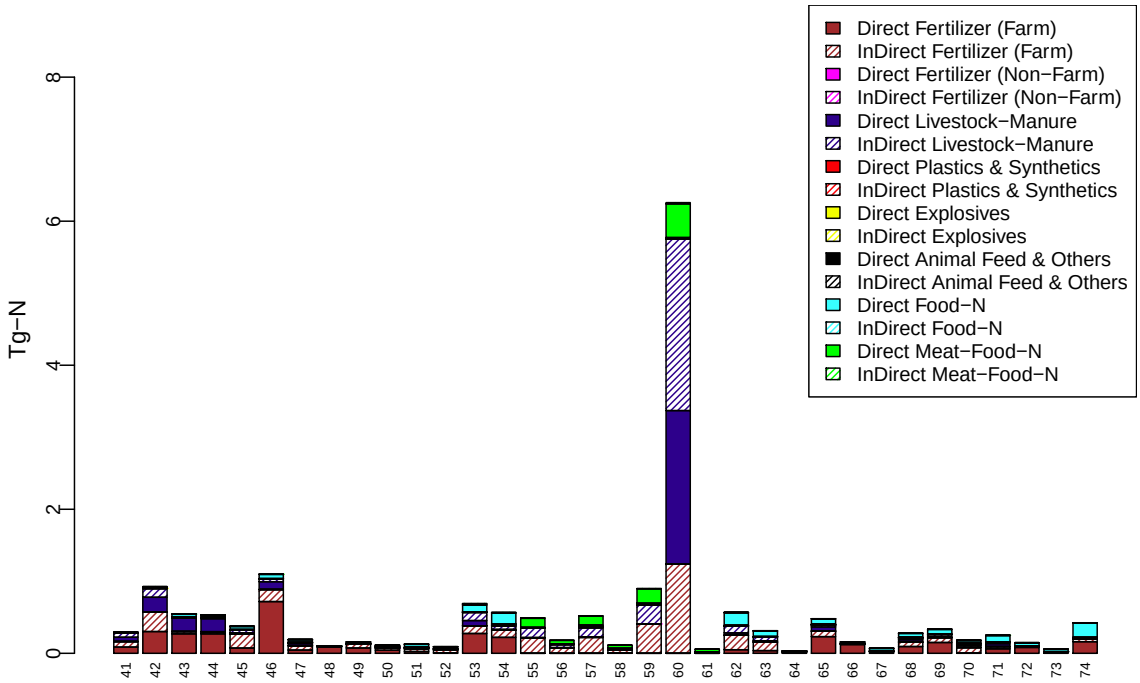

Figure S.10: N in products for aggregate sector "Food, Beverage and Tobacco (4)." Legend for x-axis is in Table S.2.

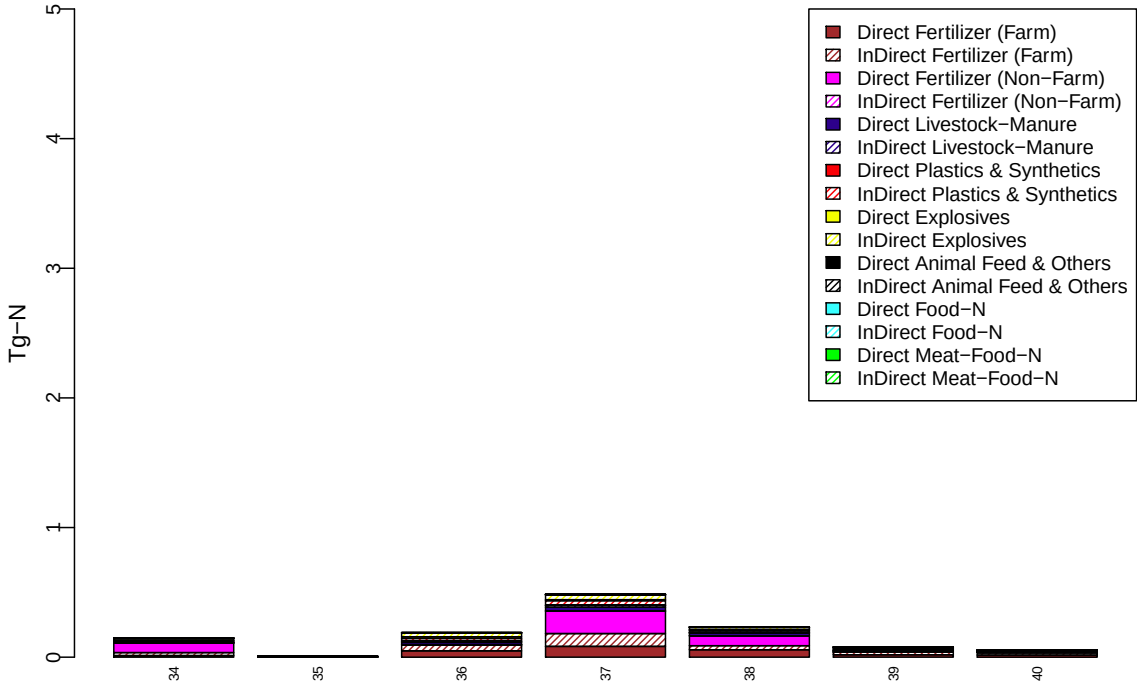

Figure S.11: N in products for aggregate sector "Construction (3)." Legend for x-axis is in Table S.2.

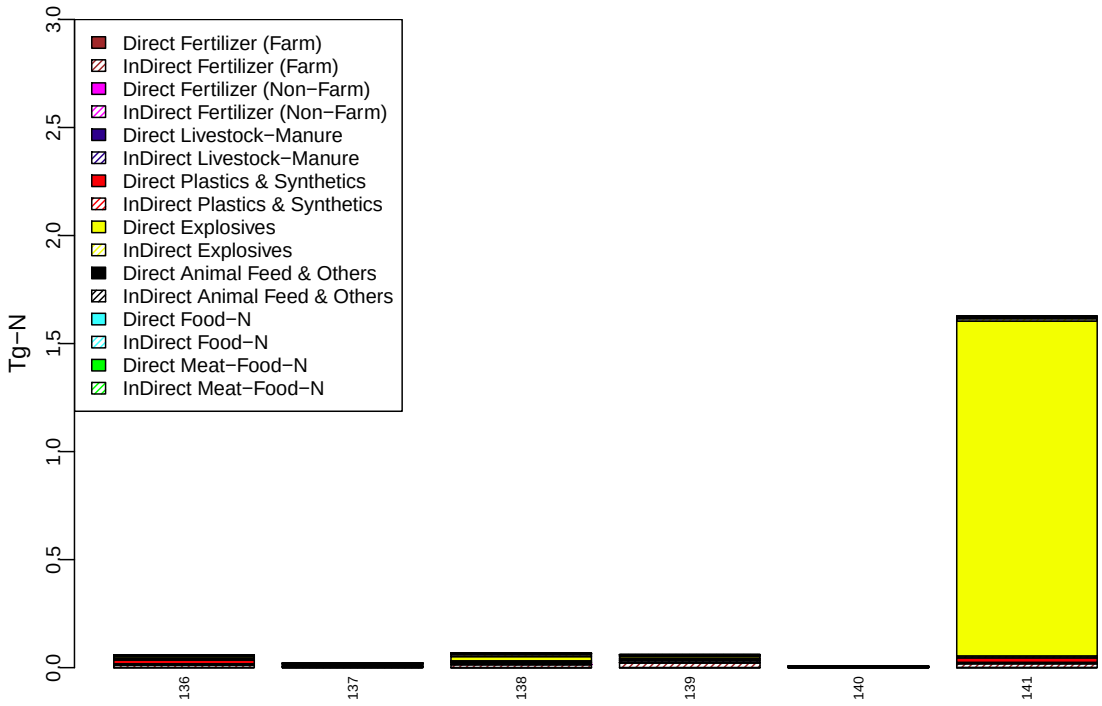

Figure S.12: N in products for aggregate sector "Paint, Adhesives, Cleaning & other Chemicals (9)." Legend for x-axis is in Table S.2.

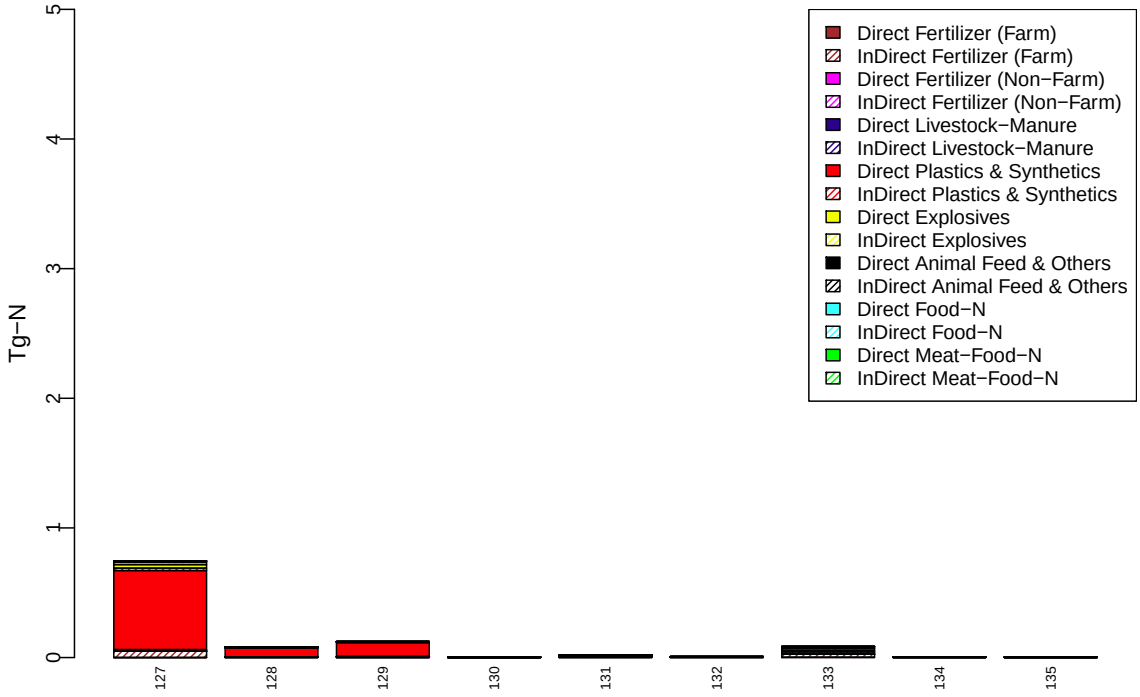

Figure S.13: N in products for aggregate sector "Resin, Rubber, Artificial fibers, Agri. Chemicals & Pharma (8)." Legend for x-axis is in Table S.2.

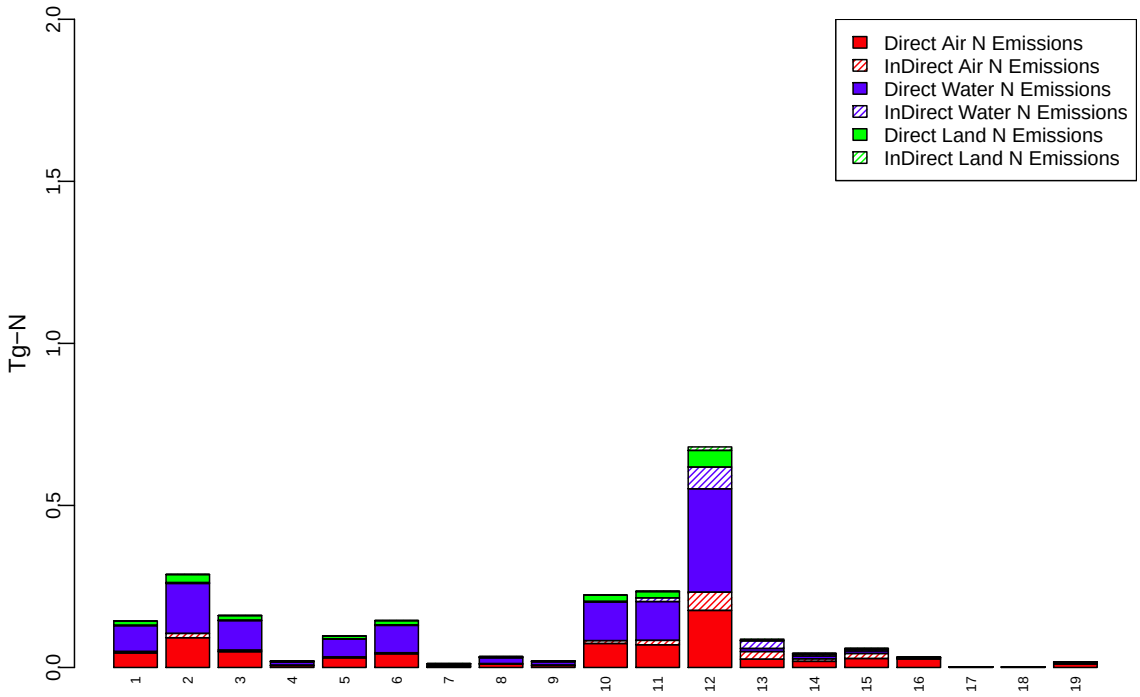

Figure S.14: N emissions from aggregate sector "Agriculture, Livestock, Forestry and Fisheries (1)." Legend for x-axis is in Table S.2.

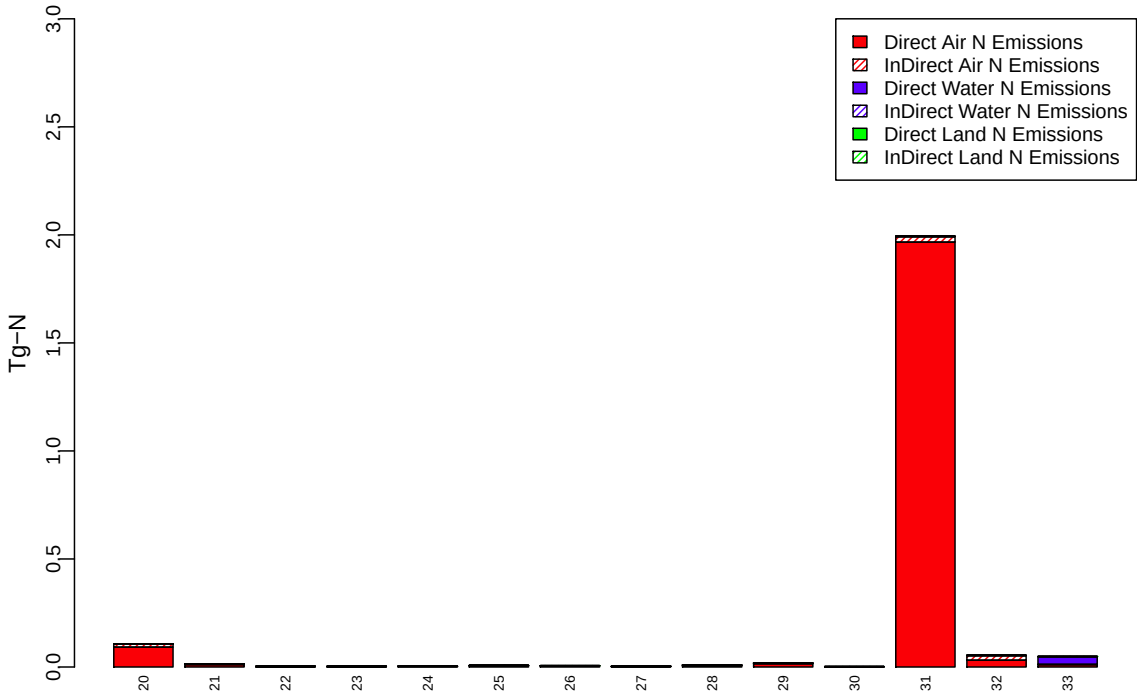

Figure S.15: N emissions from aggregate sector "Mining and Utilities (2)." Legend for x-axis is in Table S.2.

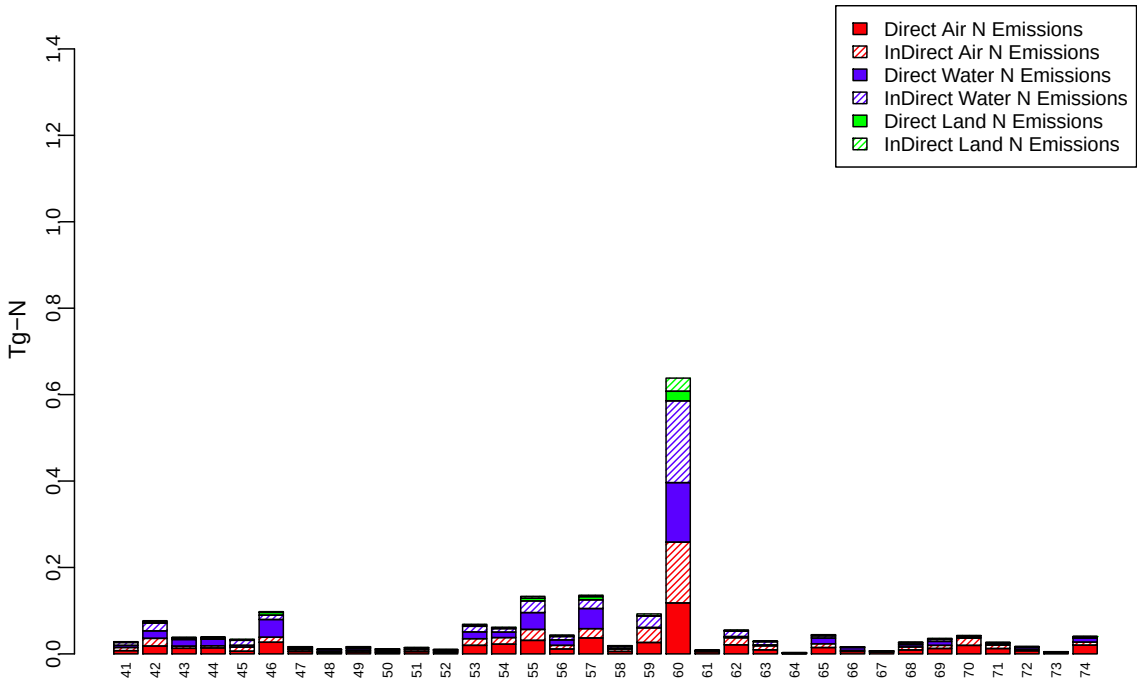

Figure S.16: N emissions from aggregate sector "Food, Beverage and Tobacco (4)." Legend for x-axis is in Table S.2.

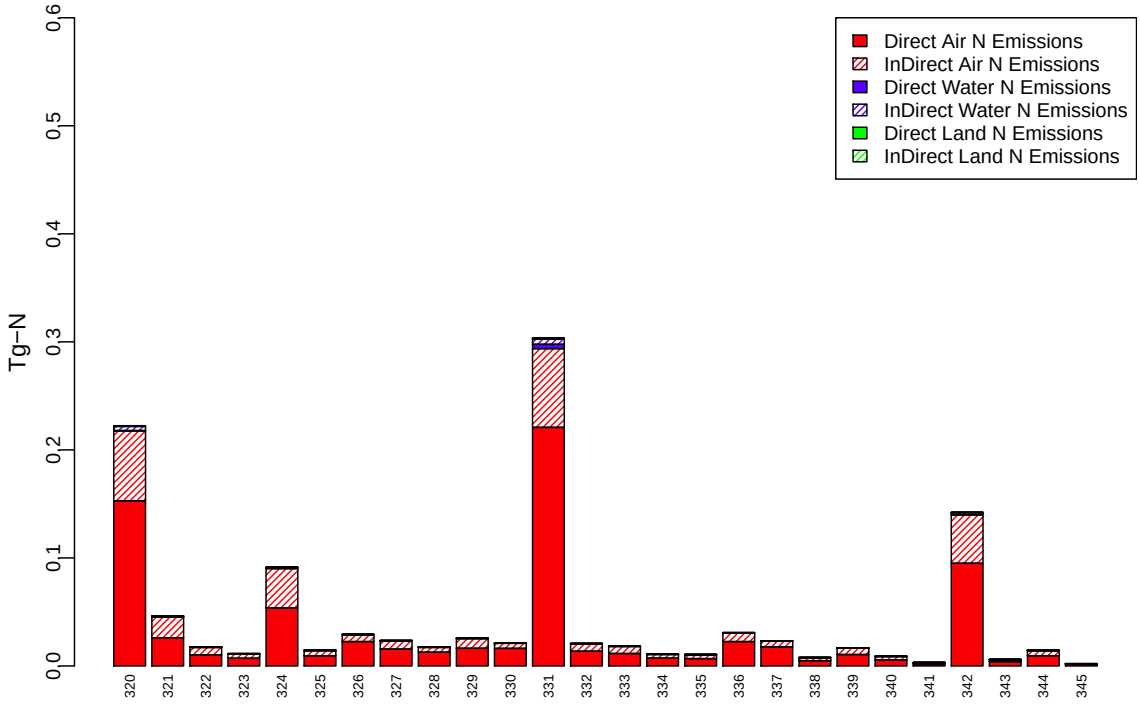

Figure S.17: N emissions from aggregate sector "Trade, Transportation & Commu. media (21)." Legend for x-axis is in Table S.2.

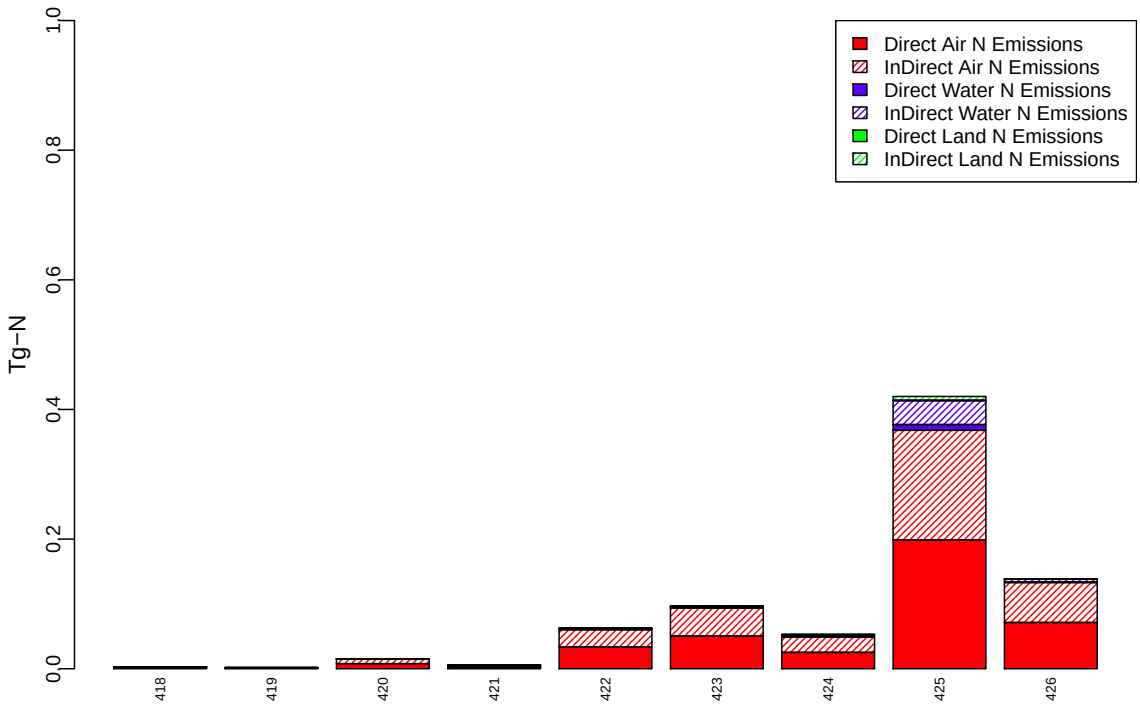

Figure S.18: N emissions from aggregate sector "Government & Special Services (28)." Legend for x-axis is in Table S.2.

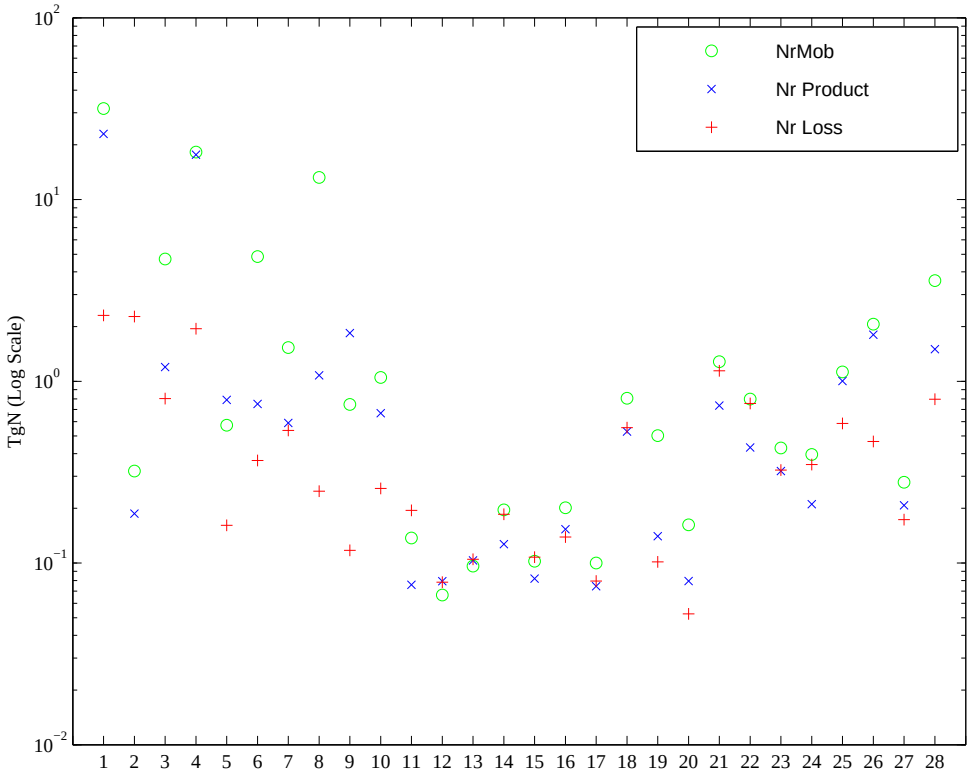

Figure S.19: Comparing N Flow Categories in Aggregated Sectors.
Legend for x-axis is in Column 4 of Table S.19 given in brackets.