National Organic Standards Board
Crops Subcommittee
Petitioned Material Proposal
Ammonia Extracts

August 3, 2021

Summary of Petition:

Note: Throughout this document references are made to the 2020 technical report (TR). It is intended that the citation of the TR inherently includes the citations of the references contained within the TR. When the TR is quoted the citations noted in the text of the TR have been removed for clarity – for a full list of references, please refer to the TR.

References to ammonia or ammonium are specifically intended to include both unless specifically stated otherwise.

Use

Ammonium extracts are used as a source of nitrogen (N) for the production of a wide range of annual and perennial crops. In the past, ammonia products have been produced via synthetic processes and have not been allowed for use in organic production. The synthetic production methods primarily use the Haber-Bosch process, and that process has allowed for widespread commercial use of nitrogen for conventional farms. From this process, urea accounts for about 50% of nitrogen fertilizers. Other common forms include aqueous ammonia, ammonium nitrate, ammonium sulfate, ammonium phosphates and other ammonium salts. Ammonia compounds can be used as bioavailable fertilizer sources and can be rapidly taken up by plants (2020 TR).

More recently, non-synthetic processes for the production of ammonium fertilizers have been developed. These processes produce high ammonia/ammonium products that can potentially be used in organic agriculture since they meet the criteria for use as non-synthetic fertilizer compounds. Before development of these non-synthetic processes for ammonia production, other N containing fertilizers have been allowed for organic use. These include, but are not limited to, soy protein hydrolysate, liquid fish products, and sodium nitrate.

Nitrogen is often a major limitation to crop yields and is biologically important as a macronutrient. It contributes to plant growth through the formation of amino acids and as the building blocks for proteins and can improve photosynthetic efficiency (2020 TR).

It should be noted that there is a wide range of ammonia/ammonium products that are approved for use in food processing and manufacturing. These include ammonium carbonate and bicarbonate which appear on the National List. Several products are approved for agricultural use, such as ammonium carbonates and ammonium soaps, but are limited by annotation to uses that do not directly contact crops.

Manufacture
While the Haber-Bosch process is the primary method for making nitrogen fertilizers, it is not relevant to organic processing and use. More recently, several methods have been developed to produce ammonia products non-synthetically. As noted in the 2020 technical report and through public comment on the two NOSB discussion papers (Fall 2020 and Spring 2021) regarding ammonium extracts, the two methods are defined as ammonia stripping and ammonia concentration:

> Ammonia stripping – ammonium compounds occur in a number of agricultural, biological, and other sewage wastes. Ammonium is commonly produced through the metabolism, hydrolysis, or anaerobic digestion of these feedstocks. Once the ammonium ions are converted to ammonia by adjusting the pH to alkaline, the ammonia is extracted from the feedstock as a gas by the use of a combination of pressurized air and/or heating. After further processing, the ammonia is reacted with an acid to re-form ammonium. This stabilizes the nitrogen at which point the ammonium can be isolated as an aqueous solution or slurry or isolated as a solid by precipitation. The direct output of the "ammonia stripping" process is a pure ammonia gas (or when cooled and distilled, a pure aqueous ammonia condensate) isolated from the original agricultural feedstock. Products produced by this method are considered novel; new products are only recently being approved and/or are still in development and not yet fully commercialized.
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> Ammonia concentration – rather than isolating only the ammonia ions, ammonia concentration uses a physical process to remove solids from the nitrogen containing liquid waste mixture. The remaining filtrate includes only water-soluble components. These include ammonia and ammonium, as well as phosphate, potash, secondary and micronutrients, and other organic compounds. This liquid is subjected to pressured air and/or heat to remove water by evaporation. This concentrates the remaining ammonium/ammonia compounds while also retaining the other nutrients and organic compounds from the original feedstock. Products produced by this method have been Organic Materials Review Institute (OMRI) listed.

The output of the stripping method produces a near pure ammonia that would be similar to that produced by the Haber-Bosch process whereas the product of ammonia concentration retains more of the original compounds of the feedstock. The specific quantities and types of nutrients in the remaining concentration vary depending on the original feedstock.

The other aspect of these concentrated and stripped ammonia products is that the nitrogen isotope ratio is different than ammonia from synthetic sources. Testing for isotope ratios of nitrogen is common. The nitrogen isotope ratio ($\delta 15N$) of natural materials also rarely falls below five and they are typically greater. Any products that go beyond this threshold (i.e., show higher $\delta 15N$ values) are almost certainly not adulterated (California Department of Agriculture, public comment, Spring 2020).

International
As discussed in the 2020 TR:

Canadian General Standards Board Permitted Substances List (CAN/CGSB-32.311-2015), Organic Production Systems Permitted Substances List - Ammonia extract is not listed in the Canadian Standards Board Permitted Substances List (CAN/CGSB- 2.311-2015); however, it does include a variety of ammonium compounds. Copper ammonia base, copper ammonium carbonate, ammonium forms of micronutrients, potassium sulfate made with ammonia reactants, and ammonium stillage are prohibited for "soil amendments and crop nutrition" uses. Ammonium carbonate is allowed "as an attractant in insect traps." Ammonium soaps are allowed "as a large animal repellent," with the stipulation that "direct contact with soil or edible portion of crop is prohibited." Ammonium lignosulphate is prohibited for "crop production aids and materials." Ammonium bicarbonate and ammonium carbonate are allowed "as leavening agent[s]." Dibasic ammonium phosphate (diammonium phosphate, DAP) is allowed as a "yeast food for use in alcoholic beverages," with the limitation that concentrations are "restricted to 0.3 g/L (0.04 oz./gal.) for cider, mead and wine."

CODEX Alimentarius Commission, Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods (CXG 32-1999) Ammonia extract is not listed in the CODEX; however, ammonium carbonates are listed in the CODEX as a "food additive."

European Economic Community (EEC) Council Regulation, EC No. 834/2007 and 889/2008 Ammonia extract is not listed in the EEC Council Regulation EC No. 834/2007 and 889/2008. However, several ammonium compounds are listed in EC No. 889/2008. Ammonium stillage is prohibited for use as a "fertilizer and soil conditioner." Diammonium phosphate is allowed as an "attractant" for traps in "pesticides and plant protection products." Ammonium molybdate is allowed as a nutritional "trace element" in animal feeds. Ammonium carbonates are allowed for the "preparation of foodstuffs of plant origin." Ammonium hydroxide is allowed for the "preparation of foodstuffs of animal origin" in gelatine production.

Japan Agricultural Standard (JAS) for Organic Production Ammonia extract is not listed in the JAS for Organic Production. However, ammonium bicarbonate and ammonium carbonate are listed in Notification No. 1606 and allowed for use as "food additives, limited to use for processed foods of plant origin."

International Federation of Organic Agriculture Movements (IFOAM) Ammonia extract is not listed in the IFOAM; however, it does list several ammonium compounds. Ammonium phosphate is allowed as an "additive," with the stipulation that concentrations are "restricted to 0.3gm/l in wine." Ammonium sulfate is allowed as an "additive," with the stipulation that it is only allowed for wine and is "restricted to 0.3 mg/l." Ammonium carbonates are allowed as "additives," with uses limited to "cereal products, confectionary, cakes and biscuits."

While not addressed specifically, sodium nitrate is not allowed in Canadian production and crops grown with sodium nitrate may not be exported to Canada. While it is unknown, comments received at the Spring 2021 NOSB meeting included concerns that the use of ammonia extracts in the United States might result in the rejection of exported products by other countries.

Summary of Review
The review of this petition has resulted in a wide variety of public comments and perspectives. These perspectives range from issues with soil health and environmental concerns, the use of multiple sources of highly soluble nitrogen fertilizers, and the potential for fraud. Commenters argued both pro and con on each of these issues.

In general, the comments from long-time organic organizations and growers tend to be in favor of the petition to prohibit ammonia extracts based on the organic principles of enhancing soil biological processes rather than applying a nutrient that is immediately available to the plant. They also noted the low carbon to nitrogen ratio, the high solubility of these extracts in terms of environmental issues, and the potential for these materials to increase the chances for fraud.

Opponents of the petition cite the need for immediately available nitrogen sources to act as a short-term nitrogen bridge. This would be needed when unusual events cause nitrogen deficits to crops and soil processes have not had a chance to recharge the available nitrogen. They also note that some use of these materials can help prevent nitrogen loss since they could allow better targeting of nitrogen applications to specific crop needs. In terms of fraud, they note that many organic nitrogen fertilizers could also be subject to fraud. Rigorous inspections, unannounced site visits, nitrogen isotope testing, and mass balance reviews make fraud very unlikely.

As noted previously, there are several materials already in the organic marketplace. These materials have been approved by OMRI and other material review organizations, although, with the caveat that nonsynthetic, liquid fertilizers that have a nitrogen analysis greater than 3 percent must comply with additional recordkeeping and inspection requirements in accordance with [NOP Guidance on the Approval of Liquid Fertilizers for Used in Organic Production (NOP 5012).] Non-synthetic fertilizers that test above 3 percent ammoniacal nitrogen are considered at higher risk for violating the soil fertility and crop nutrient management practice standards at §205.203. OMRI attaches a note that "this product contains highly soluble nitrogen and must be applied in a manner that does not contribute to the contamination of crops, soil or water. Its use must be part of an organic system plan that maintains or improves the natural resources of the operation, including soil and water quality, and comply with crop nutrient and soil fertility requirements."

Soil Health

The USDA organic regulations at § 205.203(a) requires that a producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of the soil and minimize soil erosion. At §205.203(c) and (d) the organic regulations state that the producer must manage plant and animal materials or crop nutrients and soil fertility to maintain or improve soil organic matter content.

Many commenters noted that the use of ammonia extracts runs counter to this principal by directly applying plant nutrients rather than applying nutrients that improve the biological condition of the soil. Inherently, the annotation added to high N, ammonia/ammonium containing products notes that "this product contains highly soluble nitrogen and must be applied in a manner that does not contribute to the contamination of crops, soil, or water. Its use must be part of an organic system plan that maintains or improves the natural resources of the operation, including soil and water quality, and comply with crop nutrient and soil fertility requirements." This annotation would not be added unless there was a risk that the materials do not contribute to the stated OFPA criteria. Indeed, a number of oral commenters testifying at the Spring 2020 NOSB meeting in favor of the use of ammonia extracts reinforced this by stating that ammonia extracts should not be used alone, but must be used with other soil building practices to comply with OFPA.

An example of a comment that refers to basic tenets of organic agriculture and prior OFPA and NOSB actions was submitted at the Spring 2020 meeting:

> In contrast to the reductionism of "conventional" chemical-intensive agriculture, the origins of organic agriculture are in holistic and ecological thinking. Historically, perhaps the most important principle of organic production is the "Law of Return," which, together with the foundational philosophy "Feed the soil, not the plant" and the promotion of biodiversity, provide the ecological basis for organic production. Together these three principles describe a production system that mimics natural systems. The Law of Return. In an organic system, residues are returned to the soil by tillage, composting, or mulching. While most organic growers depend on some off-site inputs, most of the fertility in a soil-based system comes from

practices that recycle organic matter produced on-site. The cycling of organic matter and on-site production of nutrients—as from nitrogen-fixing bacteria and microorganisms that make nutrients in native mineral soil fractions available to plants—is essential to organic production. The Law of Return is not about feeding plants, but about conserving the biodiversity of the soil-plant-animal ecological community. The Law of Return says that we must return to the soil what we take from the soil. Non-crop organic matter is returned directly or through composting plant materials or manures. To the extent that the cash crop removes nutrients, they must be replaced by cover crops, crop rotation, animal manures, or additions of off-site materials, when necessary. Feed the soil, not the plant.

The dictum to "Feed the soil, not the plant" reminds us that the soil is a living superorganism that supports plant life as part of an ecological community. We do not feed soil organisms in isolation, to have them process nutrients for crop plants; we feed the soil to support a healthy soil ecology, which is the basis of terrestrial life.

Biodiversity. Finally, biological diversity is important to the health of natural ecosystems and agroecosystems. Biodiversity promotes balance, which protects farms from outbreaks of damaging insects and disease. It supports the health of the soil through the progression of the seasons and stresses associated with weather and farming. It supports our health by offering a diversity of foods. Ultimately, holistically healthy, truly organic farms produce healthy plants that require far fewer applications of insecticides and fungicides (even if approved for organic production).

In the case of ammonia extracts, we are particularly interested in the principle of feeding the soil rather than the crop. OFPA §6513(b) requires that organic operations establish a plan designed to "foster soil fertility, primarily through the management of the organic content of the soil through proper tillage, crop rotation, and manuring." **Substances of high solubility, i.e., those materials that provide nutrients directly to the plant because they are quickly taken up into the plant from the soil solution, are counter to foundational organic principles, so they have always been restricted.** Such materials are listed in §205.602—Nonsynthetic substances prohibited for use in Organic Crop Production or the "prohibited naturals" section of the National List:

1) Calcium chloride is limited to treating a physiological disorder;
2) Potassium chloride must be used in a manner that minimizes chloride accumulation in the soil and;
3) Sodium nitrate is restricted to no more than 20% of the crop's total nitrogen requirement.

The organic regulations limit substances of high solubility. In the preamble to the publication of the NOP Final Rule on December 21, 2000, NOP discusses how it decided to agree with the NOSB recommendation and to put specific regulation of substances of high solubility into the annotations for each of these materials where they appear on the National List of Allowed and Prohibited Substances. NOP goes on to say, "Based on the recommendation of the NOSB, the final rule would prohibit use of these materials [substances of high solubility], unless the NOSB developed recommendations on conditions for their use and the Secretary added them to the National List." At the time, the discussion was about mined substances of high solubility because there were no concentrated, highly soluble plant nutrient materials other than mined sources available at that time. New materials of high solubility should be prohibited or restricted.

These concerns were echoed by another commenter that stated that there are significant concerns with the compatibility of purified natural ammonia with organic principles: their mimicry of conventional synthetic fertilizers and their use requires the removal of carbon value from organic waste.

There are studies that show the addition of nitrogen to nitrogen-limited fields can increase plant production. Addition of N increased production yields, biomass and thus, additional carbon resources that can be returned to the soil. Some of these studies show that the addition of nitrogen, no matter what the source, can improve soil health indices (Miner, Delgado, et al., 2020). Fertilizing nutrient-deficient soils usually results in greater crop yields. Higher yields achieve greater amounts of crop residue—roots, stems, and leaves—resulting from larger and healthier plants (Magdoff and Van Es, 2021). A caveat is that a number of these studies are conducted on conventionally treated soils and focus on nitrogen deficient systems where the addition of any nitrogen enhances plant production. If nitrogen were not deficient and additional nitrogen did not result in greater plant growth, then it is unlikely that any nitrogen addition would improve soil health indices.

Other studies show that long-term organic fertilizer inputs enrich carbon related soil functions. Manure additions can strongly influence the formation, storage and cycling of soil organic carbon and nitrogen and soil microecology (Sharaf, Thompson, et al., 2021; Ozlu, Sandhu, et al., 2019). The total amount (weights) of living organisms varies in different cropping systems. In general, soil organisms are more abundant and diverse in systems with complex rotations that return more diverse crop residues and use other organic materials such as cover crops, animal manures, and composts. When crops are rotated regularly, fewer parasite, disease, weed, and insect problems occur than when the same crop is grown year after year (Magdoff and Van Es, 2021). These biotic links can also have a positive influence on the ability of plants to resist insect pests. Plants grown in a balanced nutrient system are less likely to be attacked by pests as compared to plants that have readily available nitrogen added (Phelan, Mason, et al., 1995).

There were several public comments noting that the use of ammonia extracts could increase the rate of mineralization in soils and thus be beneficial. In a short timeframe this could be true, but this accelerated rate of mineralization could come at the cost of long-term soil carbon resources. Wang, Juliang, et al., 2018, found that long-term application of N-fertilizers causes an abundance of bacterial groups responsible for the denitrification process, which causes the turnover of nitrogen to increase and results in greater nitrogen loss over time. Essentially, adding more nitrogen fertilizer results in a long-term loss of nitrogen while altering other soil components, like decreasing soil pH and C:N ratio. When soil carbon and nitrogen are reduced in response to the application of chemical fertilizers, beneficial enzymatic activity of the soil also decreases (Ozlu, Sandhu, et al., 2019). Another study concluded:

> Annual nitrate leaching was 4.4–5.6 times higher in conventional plots than in organic plots, with the integrated plots in between. This study demonstrates that organic and integrated fertilization practices support more active and efficient denitrifier communities, shift the balance of N2 emissions and nitrate losses, and reduce environmentally damaging nitrate losses. Although this study specifically examines a perennial orchard system, the ecological and biogeochemical processes we evaluated are present in all agroecosystems, and the reductions in nitrate loss in this study could also be achievable in other cropping systems (Kramer, Reganold, et al., 2006).

Of interest is that nearly all the public comments stating that ammonia extracts help prevent environmental damage from excess application of manures and composts neglected to mention that an organic systems approach uses multiple sources of crop fertility. Comparing the use of ammonia extracts to a system that only uses manures focuses on only one part of an organic system. An organic system includes cover cropping, interplanting, and varied crops, in addition to manures and composts. This mix of fertility sources is used to mitigate issues of nutrient excesses.

> The **incorporation of crop residues and compost** [emphasis added] provides a potential long-term alternative to ammonia extract and other nitrogen fertilizers. Nitrogen content in compost is slowly released through mineralization processes in the soil, primarily facilitated by its metabolism by microorganisms in the soil. Unlike ammonia extract, the use of compost also contributes to soil organic matter, and available carbon, phosphorous, and micronutrients, as well as soil microorganism populations and activities. The incorporation of compost into the agro-ecosystem has been reported to improve soil characteristics, specifically water holding capacity and cation exchange capacity (CEC). Increased soil CEC allows it to retain cations more effectively, including ammonium ions and metal cations required as micronutrients (e.g., iron [Fe], copper [Cu], zinc [Zn]) (2020 TR)

Public comments and scientific research publications demonstrate that much more research regarding the use of these materials and of the soil health, plant health, and biological interactions is needed. There is conflicting information from studies on conventional soils and very little research conducted on organic soils. For example, a study on tomatoes in California, (Bowles, Hollander, et al., 2015) found that the complex plant and microbial processes that affect nitrogen cycling are affected by the ecology of each farm as well as between fields within a farm. Most research oriented toward nitrogen cycling takes place at research stations with fixed factors and limited soil variation. There has been little research about how nitrogen cycling occurs on working organic farms. The study detailed how organic tomato farms can achieve high yields even though tests showed relatively low nitrogen availability. They attributed this to the possibility that the nitrogen cycling was tightly coupled with tomato plant needs. While tests showed low nitrogen with respect to conventional standards, the sustained release curve of the nitrogen in those plots met plant needs. They concluded that new indicators of N availability are needed that consider active C and N processes in organic systems. This is another indicator of our lack of understanding of nutrient processes and needs in organic systems. This lack of understanding results in conclusions about the need for fast acting nitrogen applications and is problematic.

In the absence of consistent research showing overwhelming benefits from the applications of ammonia extracts, and with the requirement to fulfill OFPA criteria, use of ammonia compounds raises questions regarding soil health and the maintenance or improvement of soil organic matter. There are effective organic systems that pay close attention to nitrogen needs through the use of multiple approaches to fertility that include the basics of crop rotations and applications of manure and composts. By paying attention, these systems do not result in large buildups of phosphorous or in excessive loss of nitrogen to the environment. While there is a segment of organic stakeholders that express an interest in using these extracts, there is a larger segment that believes ecosystem management to maintain or increase soil organic matter does not include reliance on a highly soluble fertilizer.

Total Use of High N Fertilizers:
While USDA organic regulations criteria require an organic soil fertility plan to maintain or improve soil organic matter (§205.203), the interpretation of this requirement can be very difficult for certifiers to enforce. Does growing the same crop for several years, followed by a different crop, and then back to the first crop conform to this requirement? What level of highly soluble, low carbon-to-nitrogen ratio materials can be used before they are too much and do not comply with OFPA. Given the wide range of

organic soil fertility options available, it can be very difficult for certifiers to enforce a notice of non-compliance.

The restriction on the use of sodium nitrate to 20% of crop needs limits the potential for overuse of that form of highly soluble nitrogen fertilizers. In fact, the prior vote of the NOSB to completely prohibit this form of nitrogen illustrates the concern the organic community has for the use of these high nitrogen fertilizers. One comment received at the Spring 2020, meeting demonstrates the slippery slope of using these types of fertilizers, including ammonia extracts:

> Fertilizing through drip irrigation systems allows for precise placement and timing of the fertilizer for optimum crop production. Drip irrigation has become a major method of irrigating crops, especially in California. The growth in drip irrigation is driven by drought, over-draft of aquifers, and the need for more precise fertilization… The type of crops irrigated with drip irrigation include all types of vegetables, tree fruit, strawberries, cane berries, and tomatoes. Many of these crops, such as tree fruit and berries, are only irrigated using drip irrigation systems. These crops often have very long cropping cycles making it impossible to apply nutrients by a method other than through the drip irrigation system. Any fertilizing material added to drip irrigation water **must have little to no solids with most of the nutrients in a soluble form** [emphasis added]. Two of the major liquid nitrogen products are made with liquid fish (fish solubles, fish protein, fish emulsion, hydrolyzed fish) and or corn steep liquor. These ingredients contain high levels of insoluble material which cause costly plugging of drip irrigation lines.

This illustrates a system that utilizes a large amount of highly soluble fertilizer for the fertility program with little or no attention to other organic fertilizer inputs. At what point would ammonia extracts become the main source of nitrogen while other organic soil building practices become a minority?

Sodium nitrate, another highly soluble, immediately available nitrogen source is approved for organic use with a limitation to 20% of crop nitrogen needs. Like ammonia extracts, sodium nitrate is a non-synthetic alternative of bioavailable nitrogen for plants. Unlike other naturally derived substances that must undergo mineralization to be plant available, ammonia extracts and sodium nitrate act more like conventional fertilizers. The 2020 TR cites a number of sources that demonstrate the benefits of materials that need to undergo mineralization as opposed to those that are immediately available and states:

> Many substances derive from natural products that are allowed as organic fertilizers, including fish meal, liquid fish residues, feather meal, bird or bat guano, alfalfa meal, soybean meal, bone meal, kelp, seaweed, blood meal, and meat meal. Like crop residues and compost, organic fertilizers require additional mineralization processes and provide a slow release of nitrogen, which is primarily present in complex molecules. Like crop residues and compost, organic fertilizers also contribute to increased soil organic matter, CEC capacity, and other nutrients and micronutrients. Unlike nitrogen fertilizers used in conventional agriculture, organic fertilizers have been reported to have minimal negative to long-term positive effects.

There is the potential to use multiple sources of low C:N ratio, high bioavailability fertilizers to replace basic soil fertility methods such as crop rotation, intercropping, and appropriate manure and compost use. Traditional organic materials, with the exceptions of sodium nitrate and guano, have a C:N ratio above 3:1 :

Material	C:N ratio range
Sodium nitrate	0.02: 1
Sea bird guano	1.2 - 3.3: 1
Blood meal	3.1 - 3.8: 1
Fish powder	3.4 - 4.0: 1
Feather meal	3.5 - 3.8:1
Bone meal	3.6: 1
Liquid food-based fertilizer	4.6-5.2: 1
Liquid fish emulsion	5.2: 1
Cotton seed	5.5: 1
Poultry litters	8-12: 1
Composts	10.7 - 99.3:1
Soil	10-12
Clover and alfalfa (early)	13
Alfalfa meal	15.9: 1
Dairy manure (low bedding)	17
Alfalfa hay	20
Green rye	36
Corn stover	60
Wheat, oat, or rye straw	80
Oak leaves	90
Fresh sawdust	400
Newspaper	600

Sources: Cassity-Duffey, Cabrera, et al., 2020; Hartz and Johnstone, 2006; Lazicki, Geisseler, et al., 2020; Magdoff and Van Es, 2021.

Ammonia extracts have C:N ratios below 3:1 as compared to other liquid products:

Type of product	Ammonia-N (%)	Total N (%)	Ammonia-N/Total N (%)	C:N
manure tea	0.003 - 0.42	0.09 - 0.71	3.3 - 59.2	17:1
restricted ammonia product	4.2 – 7.47	5.78 – 8.23	51.0 – 99.6	2:1
liquid fish fertilizer	0.4 - 0.95	3.96 – 5.25	7.6 – 20.7	3.35
anaerobic digestate	0.048 - 0.68	0.28 – 2.21	2.2 – 43.2	1.25 - 5.48

Source: OMRI

Any amendment that is over 40:1 can cause temporary plant nitrogen deficits since nitrogen must be taken from surrounding soil to enable breakdown of these materials. Conversely, amendments with lower C:N ratios can contribute available nitrogen to the system (Magdoff and Van Es, 2021).

As written by one public commenter (Spring 2021):

> The prohibition of synthetic nitrogen fertilizers manufactured through the Haber-Bosch process is a longstanding and fundamental prohibition in organic agriculture. The proliferation of these fossil-fuel based synthetic fertilizers in conventional agriculture was a primary motivator of the modern organic agricultural movement. The principles of organic (as described in the 2001 NOSB Recommendation) seek to achieve agricultural and environmental goals through the "use of cultural,

> biological, and mechanical methods, as opposed to using synthetic materials to fulfill specific functions within the system." Therefore, substances that mimic the chemistry and functionality of synthetic nitrogen fertilizers can understandably be considered as equally incompatible with traditional organic principles. Purified natural ammonia and ammonium compounds mimic conventional synthetic nitrogen

Another commenter stated:

> Highly soluble sources of nitrogen cannot be addressed in a vacuum, and we cannot look at one material at a time. We must take a broader approach to limiting highly soluble sources of nitrogen as a whole. To evaluate and list each individually, even with a restriction, is a slippery slope and raises the concern of "stacking." [Question #4 of the Spring 2020 Discussion document] asks: "Should the use of natural ammonia extract be limited to a certain percent of nitrogen use in crops (similar to the Chilean nitrate restriction)?" With this approach, producers could potentially "stack" highly soluble sources of nitrogen, using 20% of the crop's needs from Chilean nitrate, 20% of the crop's needs from another source, and 20% of the crop's needs from yet another source.

Products that are immediately plant bioavailable mimic conventional nitrogen sources. Products that require additional mineralization, such as protein sources, require soil biotic transformation to be bioavailable to plants. While not perfect, organic products with greater than a 3:1 C:N ratio fit into the category of materials that require soil biotic transformation. Non-synthetic products that are below a 3:1 ratio tend to be those that are immediately plant available.

Fraud potential

While the potential for fraud is not specifically referenced in OFPA, it does affect the ability of certifiers and the NOP to evaluate whether organic standards are being followed by crop producers. Given additional emphasis on organic enforcement and that both the petitioner and public commenters are concerned with the potential for fraud with these ammonia extracts, it seems prudent to note the issues. However, commenters have noted that the potential for fraud exists with many fertilizers.

OMRI stated in public comments that it conducts audits and inspections of high nitrogen liquid fertilizer (HNLF) facilities twice a year. NOP guidance states that "the material evaluation program must…Conduct a balance-in/balance-out analysis of all ingredients and finished products including, when appropriate, by nitrogen content." A mass balance exercise should expose fraudulent uses of synthetic nitrogen. If concentrated ammonia products of concern are those liquid fertilizers with above 3% ammoniacal nitrogen, they are considered HNLF and subject to regular mass balance audits. Formulations that may contain less than 3% ammoniacal nitrogen would not be subject to the same requirements, so the risk of adulteration remains. However, that risk already exists for all liquid fertilizer products that are not subject to inspection. OMRI's inspectors certainly encounter challenges in completing mass balance calculations for complex formulations, particularly those derived from waste stream materials. OMRI therefore is not suggesting that the mass balance calculation is an absolute fail-safe measure against fraud, but rather a risk mitigation measure.

In terms of N15 to N14 isotope ratio testing, OMRI expressed its concerns in public comments at the Fall 2020 NOSB meeting. OMRI no longer requests isotope ratio testing due to the unreliability of test results for complex blended formulations.

A public commenter, citing a study from the University of California presented a different perspective. The University determined that there is a very marked difference in N15 isotope concentration between natural and synthetic ammonia, and the test for determining nitrogen isotopes in products is common.

The nitrogen isotope ratio (δ15N) of natural materials also rarely falls below a certain threshold, with a few exceptions. Fish tissue and guano, for example, do not have ratios less than 5, and they are typically greater. Any products that go beyond this threshold (i.e., show higher δ15N values) are almost certainly not adulterated. It is important to note, however, that plants that rely on symbiotic nitrogen uptake can have δ15N values as depleted, or close to atmospheric values, as nonorganic nitrogen sources. So, in fertilizers where biomass from nitrogen-fixing plants (e.g., legumes) has been added, it may be difficult to distinguish them from nonorganic sources. (http://californiaagriculture.ucanr.edu • OCTOBER–DECEMBER 2013)

The California Department of Agriculture submitted public comments that state they can use isotope ratios and inspections to prevent fraud:

> Concerns about fraud, i.e., fraudulent use of synthetic materials to produce organic input materials, have prompted calls to employ stable isotope techniques to help detect adulteration of organic liquid ammonia products with synthetic ammonium. Therefore, the potential usefulness and limitations of stable isotope testing will be discussed below. Nitrogen-containing materials have unique isotope ratios, or "isotopic signatures." In a solution, N isotope ratios [15N/(14N+15N)] are uniform and stable, and measurements by isotope mass spectrometers are repeatable with great precision.
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> Therefore, adulteration of an organic liquid ammonia product can be detected if the isotopic signature of a product is different from that obtained of the same product analyzed earlier, for example right after its manufacture. Comparing N isotope ratios of finished product batches with those of products offered in the marketplace can bring adulteration to light. CDFA-OIM measures the isotopic signature of finished liquid ammonia product batches at the manufacturing sites. The N isotopic signatures of products in the channels of trade must match the ones in the records.
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> While changes of the isotopic signature of a given product can reliably be detected, using stable isotopes to distinguish between organic and synthetic sources of N is more problematic. The differences in N isotope ratios, or isotopic signatures, occur due to discrimination against the heavier (15N) isotope during biochemical and physical processes, such as soil-to-atmosphere fluxes of N gases. The N isotopic signature of the atmosphere, the source of synthetic N, is generally lower than that of organic materials. Thus, the N isotopic signatures of ammonium from organic sources are slightly, but consistently, higher than those of ammoniacal-N in synthetic fertilizer…
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> It is not possible to use the isotopic signature alone to verify the integrity of the OIM liquid ammonia manufacturing processes due to the fact that there is a wide range of N isotope ratios among organic sources of N that in some cases overlap those of synthetic fertilizer. Thus, isotopic signatures are useful for discovering fraud committed in the channels of trade, but not as a tool to determine whether a product has been made solely from non-synthetic source materials. CDFA-OIM relies on thorough inspections of manufacturing plants, including N mass balance audits at announced and non-announced visits to deter fraud by manufacturers of organic liquid ammonia products.

Other comments received at the Fall 2020, and Spring 2020, noted that the overlap in isotopic ratios between synthetic and natural ratios makes using isotope ratios alone difficult. Without extensive sampling of the exact ratios of lots at manufacture and at use, the chance for comixing or ammonia products exists. Other commenters noted that, while California is deliberate about testing, their purview does not extend nationally or internationally. Likewise, adulterations at the farm scale are possible and farm inspections are often performed after nitrogen has been applied to crops.

A public comment from the Spring 2020 meeting notes:

> Certifiers already face an uphill battle with those clients who treat soil as merely something to hold plants up and do all feeding through liquid injection rather than soil building. Adding more successful liquid to the system is just not in keeping with the intent or spirit of organic farming. How to stop people from cheating is also a major hurdle. Cheating has historically been an issue in making similar products by spiking them with synthetic nitrogen, and it is also an issue in users becoming too dependent on these products at the expense of cover crops, compost, and other fundamental organic practices.

Finally, several commenters stated that the potential for fraud is increased when there is a significant cost difference between the biological ammonia fertilizers and the synthetic materials. The cost differences create an economic incentive for comingling products and presenting them as products approved for organic use. While legal penalties deter fraudulent activity, NOP enforcement activities have demonstrated that economic gains continue to motivate fraudulent activities.

Category 1: Classification

1. For CROP use: Is the substance **X Non-synthetic** or **Synthetic?**
   Is the substance formulated or manufactured by a process that chemically changes a substance extracted from naturally occurring plant, animal, or mineral sources? [OFPA §6502(21)] If so, describe, using NOP 5033-1 as a guide.

   The processing of ammonia extracts does not change the form of the ammonia/ammonium product. Naturally occurring biological processes, such as anaerobic digestion and fermentation, can be used to produce ammonia and ammonium compounds. While the production of ammonia and ammonium compounds (ammonia extract) occurs through natural, biological processes, isolation via ammonia stripping generally utilizes acid and base reactions. The classification of ammonia extract as synthetic or nonsynthetic is dependent on the identity of the acids and bases used in the production of ammonia extract. According to NOP decision trees, the use of synthetic substances for pH adjustment or other processing would result in the classification of the ammonia extract as synthetic, while the use of natural acids and bases would result in the classification of ammonia extract as nonsynthetic (2020 TR).

2. Reference to appropriate OFPA category:
   Is the substance used in production, and does it contain an active synthetic ingredient in the following categories: [§6517(c)(1)(B)(i)]; copper and sulfur compounds; toxins derived from bacteria; pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals; livestock parasiticides and medicines and production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleansers; or (ii) is used in production and contains synthetic inert ingredients that are not classified by the Administrator of the Environmental Protection Agency as inerts of toxicological concern?

   Ammonium extracts do not include an active synthetic ingredient.

Category 2: Adverse Impacts

1. What is the potential for the substance to have detrimental chemical interactions with other materials used in organic farming systems? [§6518(m)(1)]

   To the extent that the application of ammonia/ammonium extracts can affect soil pH and other microbial processes, other nutrients may or may not be released based on the soil pH effects.

2. What is the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment? [§6518(m)(2)]

   Ammonia, ammonium, and their byproducts have short lifetimes in the environment, typically ranging from hours to days based on environmental conditions. The short environmental lifetimes of ammonia, ammonium, and their by-products are due to the bioavailability of nitrogen in these compounds, which are readily incorporated into amino acids and other biologically important molecules. The exception in the byproducts of ammonia and ammonium ions is the oxidation product nitrous oxide (dinitrogen oxide [N_2O]), which can persist for approximately 120 years in the atmosphere. When excess ammonia is present in the environment, it is likely to volatize and move into the atmosphere as a gas (2020 TR).

   Furthermore, the TR states that the high-water solubility of ammonia, ammonium and nitrate ions makes them conducive to leaching into water ecosystems. While these compounds can be metabolized by aquatic microorganisms, if they are overabundant eutrophication can occur and ammonia and ammonium can be toxic to aquatic life. Algal blooms can be caused by the influx of high concentrations of nitrogen nutrients. Algal blooms can reduce oxygen concentrations and result in hypoxic and anoxic environments.

3. Describe the probability of environmental contamination during manufacture, use, misuse or disposal of such substance? [§6518(m)(3)]

   The production of ammonia extracts can result in the release of ammonia to the environment. This is expected due to the inability of ammonia isolation processes to capture 100% of the ammonia content of feedstocks. The efficiency of capture depends on the feedstock and isolation conditions, but is reported to be in the range of 17-95% of total ammonia content with a 90% recovery considered acceptable. The remaining ammonia is lost to the environment either as a gas or as residual amounts that remain in the feedstock effluent (2020 TR).

   Other issues of environmental contamination are true of all ammonia compounds and are not specific to non-synthetic ammonias. The release of these compounds to the atmosphere can contribute to degradation of air quality and visibility due to the formation of ammonium aerosols. Additionally, the primary issue of environmental contamination is the over application of nitrogen products and their subsequent leaching into non-agricultural environments. Dramatic losses of 20-80% have been noted. (2020 TR).

   Finally, the disposal/use of the feedstock material that remains after filtration and/or ammonia isolation has not been mentioned in the TR or from public comments. Depending on the use of that feedstock there are potential environmental issues with that remaining material. Comments have focused on issues with phosphorous increases and issues when using manures/composts. This same problem could be an issue when a feed stock is disposed of after ammonia has been removed.

4. Discuss the effect of the substance on human health. [§6517(c)(1)(A)(i); §6517(c)(2)(A)(i); §6518(m)(4)].

   FDA allows the use of a number of ammonium substances or lists them as Generally Recognized as safe. However, these substances differ from those used in agriculture.

   The 2020 TR refers to several human health effects. Ammonium is a positive ion and its effect on human health are dependent on the remaining negative portions of the ionic compound Ammonium ions play a critical role in the Krebs cycle.

   Ammonia is classified as a respiratory irritant – long term exposure to gaseous ammonia can result in bronchial or pulmonary inflammation. Repeated exposure can lead to pulmonary fibrosis. Direct inhalation or ingestion can cause esophageal burns.
5. Discuss any effects the substance may have on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock. [§6518(m)(5)]

   The 2020 TR states:
   Ammonia and ammonium compounds can readily migrate from the applied soil system into the atmosphere and marine environments. When ammonia and ammonium compounds remain in their applied soils, they also induce changes to the local environment. The acidity of ammonium ions is recognized as a cause of soil acidification, reducing the soil pH. These pH changes result in changes to the solubility and bioavailability of other nutrients, affecting both crops and soil organisms. Changes to soil pH may also have negative impacts on the viability of soil organisms, including earthworms and various microbial populations. High soil concentrations of ammonia and ammonium have been shown to retard the natural nitrogen fixation processes of plants. This shift in natural ammonia production reduces the natural efficiency of the soil, making it more reliant on continued nitrogen inputs. The release of ammonia to the atmosphere directly contributes to ozone depletion and global warming (ammonia is a greenhouse gas). Ammonia and ammonium compounds contribute to the degradation of air quality and visibility due to the formation of ammonium aerosols. The production of nitric oxide and nitrous oxide contribute to ozone depletion.

6. Are there any adverse impacts on biodiversity? (§205.200)

   The use of high nitrogen available fertilizers can alter the uptake rates of nitrogen and alter plant nutrient production. Studies by Phelan, Mason, et al., 1995, demonstrate that these altered plant nutrient production cycles can lead to increased susceptibility to pests.

   Other studies show that long-term organic fertilizer inputs enrich carbon related soil functions. Manure additions can strongly influence the formation, storage and cycling of soil organic carbon and nitrogen and soil microecology (Sharaf, Thompson, et al, 2021; Ozlu, Sandhu, et al., 2019). The total amounts (weights) of living organisms vary in different cropping systems. In general, soil organisms are more abundant and diverse in systems with complex rotations that return more diverse crop residues and that use other organic materials such as cover crops, animal manures and composts. When crops are rotated regularly, fewer parasite, disease, weed, and insect problems occur than when the same crop is grown year after year (Magdoff and Van Es, 2021)

There were several public comments noting that the use of ammonia extracts could increase the rate of mineralization in soils and thus be beneficial. In a short timeframe this could be true, but this accelerated rate of mineralization could come at the cost of long-term soil carbon resources. Wang, Juliang, et al., 2018, found that long-term application of N-fertilizers causes an abundance of bacterial groups responsible for the denitrification process, which causes the turnover of nitrogen to increase and results in greater nitrogen loss over time. Essentially, adding more nitrogen fertilizer results in a long-term loss of nitrogen while altering other soil components, like decreasing soil pH and C:N ratio. When soil carbon and nitrogen are reduced in response to the application of chemical fertilizers, beneficial enzymatic activity of the soil also decreases (Ozlu, Sandhu, et al., 2019). Another study concluded:

> Annual nitrate leaching was 4.4–5.6 times higher in conventional plots than in organic plots, with the integrated plots in between. This study demonstrates that organic and integrated fertilization practices support more active and efficient denitrifier communities, shift the balance of N2 emissions and nitrate losses, and reduce environmentally damaging nitrate losses. Although this study specifically examines a perennial orchard system, the ecological and biogeochemical processes we evaluated are present in all agroecosystems, and the reductions in nitrate loss in this study could also be achievable in other cropping systems (Kramer, Reganold, et al., 2006).

The TR states that the incorporation of crop residues and compost provides a potential long-term alternative to ammonia extract and other nitrogen fertilizers. Nitrogen content in compost is slowly released through mineralization processes in the soil, primarily facilitated by its metabolism by microorganisms in the soil. Unlike ammonia extract, the use of compost also contributes to soil organic matter, and available carbon, phosphorous, and micronutrients, as well as soil microorganism populations and activities.

Category 3: Alternatives/Compatibility

1. Are there alternatives to using the substance? Evaluate alternative practices as well as non-synthetic and synthetic available materials. [§6518(m)(6)]

   The following statements are taken from the 2020 TR.

   There are many natural soil amendments that can be used to deliver nitrogen for crops. Manure is a source of nitrogen compounds, including ammonia, ammonium ions, and urea, which are biological waste compounds. However, manure has a relatively low level of biologically available nitrogen compared to ammonia extract. The biologically available forms of nitrogen in manures may also lead to similar issues with nutrient leaching as ammonia extract, potentially polluting surrounding water systems and leading to atmospheric ammonia emissions. Manure from both organic and conventional livestock is permitted for use in the production of organic crops. However, the availability of manure may be limited regionally due to the continued segregation of crop and animal agricultural production.

In addition to manure, crop residues and compost may be added as a source of bioavailable nitrogen. This includes the direct integration and composting of both manure and other organic agricultural wastes. The high protein and amino acid content of these feedstocks allows for their conversion to ammonia and ammonium compounds through anaerobic digestion and metabolism by soil microorganisms. When composts do not include manures, they are generally low in nitrogen containing compounds (2020 TR).

The incorporation of crop residues and compost provides a potential long-term alternative to ammonia extract and other nitrogen fertilizers. Nitrogen content in compost is slowly released through mineralization processes in the soil, primarily facilitated by its metabolism by microorganisms in the soil. Unlike ammonia extract, the use of compost also contributes to soil organic matter, and available carbon, phosphorous, and micronutrients, as well as soil microorganism populations and activities. The incorporation of compost into the agroecosystem has been reported to improve soil characteristics, specifically water holding capacity and cation exchange capacity (CEC). Increased soil CEC allows it to retain cations more effectively, including ammonium ions and metal cations required as micronutrients (e.g., iron [Fe], copper [Cu], zinc [Zn]) (2020 TR).

Chilean nitrate (mined sodium nitrate) is a natural source of bioavailable nitrate ions. Sodium nitrate offers a natural alternative to ammonia extract as a nitrogen fertilizer, and is the historical source of nitrogen fertilizer prevalent before the advent of the Haber-Bosch process. Nitrate has been shown to be less toxic to terrestrial and aquatic organisms than ammonium ions, although it is toxic to some species at high concentrations. However, nitrate is more likely to contribute to environmental contamination than ammonium, and is the primary nitrogen compound associated with leaching into aquatic systems. Sodium nitrate is highly water soluble and may leach into aquatic systems as run-off. Nitrate also contributes to atmospheric contamination in the form of various nitrogen oxide compounds that are formed through denitrification reactions (2020 TR).

Many other substances derived from natural products are allowed as organic fertilizers. These include fish meal, liquid fish residues, feather meal, bird or bat guano, alfalfa meal, bone meal, kelp, seaweed, and meat meal. These materials may be more readily available to crops due to their low C:N ratio, but all require mineralization to be plant bioavailable. The mineralization is required due to the nitrogen available in these materials being present as more complex molecules and proteins. These materials provide a slower N release than ammonia extracts. They also contribute to increased soil organic matter, CEC capacity and other nutrients and micronutrients. Unlike conventional fertilizers, organic fertilizers have been reported to have minimal negative to long-term positive effects on soil health (2020 TR).

Crop rotation and intercropping are traditional methods to ensure soil health. They can be especially effective if legumes are included in the rotations. Legumes have the ability to fix nitrogen from the atmosphere by converting atmospheric dinitrogen into bioavailable nitrogen. Legumes and other nitrogen-fixing plants produce higher quantities of bioavailable nitrogen when there are low soil concentrations of ammonia and ammonium. Intercropping offers the potential of direct input of bioavailable nitrogen from legumes to other crops by growing them alongside each other. Intercropping has been shown to increase crop yields and these yields have been shown to be less dependent on nutrient inputs compared to monocropping systems. Cover cropping also promotes increased organic matter, increases CEC properties, and prevents soil erosion. Cover crops use can be limited by regional climates and require adequate soil temperatures to grow between agricultural seasons (2020 TR).

2. In balancing the responses to the criteria above, is the substance compatible with a system of sustainable agriculture? [§6518(m)(7)]

   To further evaluate compatibility, the Subcommittee review includes answers to the following 12 questions as noted in the NOSB Policy and Procedures Manual

- **Does the substance promote plant and animal health by enhancing the soil's physical chemical, or biological properties**?

  A number of public commenters from the Spring, 2021, NOSB meeting indicated that ammonia extracts must be used with other soil building practices in order to comply with OFPA criteria. These comments would indicate that the use of ammonium extracts alone do not enhance the soil's biological properties. For example:

  > The Petition ignores that the use of any fertilizer, including presently approved ammonia extracts, can only be applied under a holistic certified organic system plan

  This is a complex issue and commenters also provided a range of responses that either indicated that these extracts would harm soil biological properties or that they would enhance these properties. However, it seems contradictory that proponents of ammonia extracts state that they must be used with other organic soil building materials to comply with OFPA. They then turn around and argue that these extracts promote soil biological properties and soil health.

  Of particular note, the comments supporting the use of ammonia extracts were often referring to extracts produced using the concentration method. This method simply concentrates the ammonia containing materials by the removal of water. The carbon and other nutrients are not removed and thus these materials are not the nearly pure ammonia product that is derived from the stripping method. Thus, from comments received it may be important to distinguish these two types of ammonia materials since they cause different soil effects:

  > For instance, "ammonia concentration" can result in innumerable combinations and concentrations of ammonia salts, minerals, and organic matter depending on the starting feedstock used for the digestate as well as the concentration method (e.g., filtration versus evaporation, etc.), resulting in different types and concentrations of biofertilizers (e.g., liquid versus granular). Therefore, the interactions with plants, soil, and microbial communities will differ depending on the resulting end-use formula of the concentrate. In contrast, "ammonia stripping" results in specific ammonia compounds: some variation of ammonium salt depending on the acid used to trap (stabilize) ammonia gas at the end of the stripping process. Ammonia stripping from anaerobic digestion of animal manure, simply put, converts ammonium from organic matter (NH4) to ammonia (NH3) gas, which is then typically absorbed in an acid solution to create ammonium sulfate or ammonium nitrate

  Additionally, commenters often compared the use of all types of ammonia extracts in relation to the use of manures and composts. These references noted the use of manures and composts can create potential for increased phosphorous levels in the soil, nitrogen leaching in seasons where crops are not present and other environmental issues:

> Concerns about damage to the health of the soil system are not unjustified when applying ammonium fertilizers. However, these problems are not any more pronounced with ammonium fertilizers than they are with fertilizers in general. In fact, the targeted use of liquid fertilizers can be less damaging to the soil ecosystem and surrounding water systems than the application of large amounts of manure or even compost, which are both commonly used in organic systems to supply nitrogen

However, other commenters (see comments submitted by Hatfield) noted that a good organic soil program does not rely solely on manures and composts, but also incorporates crop rotations, cover crops and interplanting. In order to avoid phosphorus or calcium build up in the soils after manure or compost application, a complete wholistic approach is necessary for the organic farming system as OFPA states. Crop rotations that cycle between high and low consumption or nitrogen in addition to cover crops in the off-season or intercropping with cover crops during the season help reduce the dependency of consecutive topical applications of manures or compost that can leave phosphorus deposits over time. If phosphorus deposits over time occur, then switching to forage grasses such as alfalfa or other forms of hay can assist in "growing out" the soil problems over time, but the soil will need to be remediated if excesses exist and not ignored for long term soil health and viability. The use of these methods can limit the potential for environmental issues that could result from manure use alone. And, in fact these diverse soil fertility practices can increase soil biological activity:

> The impact of soil carbon on soil biological response was more closely related to the inputs of carbon due to crop rotations than fertilizer practice (Geisseler, 2014). These complexities have been explored by Hijbeeks et al. (2017) when they compared soil and crop responses to organic and inorganic fertilizers on a range of crop from long-term experiments across Europe. Their results showed no significant effect of the organic inputs on crop yield with the effects from organic additions dependent upon the clay content, climate, and the soil organic matter at the beginning of the experiment as shown from their results (Fig. 4). These findings are consistent with those from Lori et al. (2017) in their meta-analysis of 56 experiments across the world. They found organic systems exhibited 32-84% greater microbial biomass carbon, microbial biomass nitrogen, total phospholipid fatty acids, and dehydrogenase, urease, and protease activities than conventional systems. When they used subgroup analyses, they found that crop rotation, inclusion of legumes in the rotation, along with the organic inputs were all significant factors affecting the soil microbial size and activity.

There were few comments comparing the environmental effects of any type of ammonia extract to a complete organic system using manures, composts, crop rotations, cover crops and interplanting. Several commenters wrote that this is an area where research is limited, and effects may largely be unknown.

Given that the comments and citations supporting the use of ammonia extracts generally compare these extracts to the use of manures and composts rather than whole soil systems, that these materials can only be used in conjunction with other carbon contributing soil practices, and that some research indicates their negative effects on soil biology, a conservative approach to this answer is that the use of these extracts does not positively contribute to plant health over the long term.

- **Does use of the substance encourage and enhance preventative techniques including cultural and biological methods for management of crop**, livestock, and/or handling operations?

  As noted by commenters, the use of ammonia extracts must include the uses of other cultural and biological processes to meet the OFPA criteria for maintaining or increasing soil organic matter. The ammonia extracts themselves do not encourage or enhance preventative techniques for crop management.

  Commenters have argued that the limited use of these materials, in situations where nitrogen might be limited due to unusual weather events or cold soils, could "prime" the soil system to increase biological activity or to bridge short term nitrogen deficits. But these situations do not meet the criteria of the wording "encourage and enhance preventative techniques" since they would be a response in an unusual situation when other techniques have failed. Others have noted that if soils are wet or cold during planting time, this points to inefficiency of the mycorrhizal fungi or the root system itself. Nitrogen is not generally needed in large amounts early on, and it is actually phosphorus that is needed. If mycorrhizal fungi are not active due to weather, they cannot process the needed phosphorus to assist with early plant germination. Even in excess phosphorus soils, there can be a phosphorus deficit in the plants when cold / wet soils occur. With the viewpoint of conventional farmers, a true starter fertilizer is actually 10-34-0, indicating more phosphorus is needed early on to charge the soil for the plant "pop-up" than nitrogen itself. This same issue goes for an organic soil.

  Additionally, the purified ammonia compounds require the removal of the carbon value of organic waste, either through filtration or by stripping. In the past, the NOSB has prohibited materials sourced from agricultural waste when the carbon value of the original source material was not retained in the final product. The prohibition of ash from manure burning is an example where the carbon from the manures is removed by burning and the value of the materials for restoring soil organic matter is destroyed.

- **Is the substance made from renewable resources? If the source of the product is non-renewable, are the materials used to produce the substance recyclable? Is the substance produced from recycled materials? Does use of the substance increase the efficiency of resources used by organic farms, complement the use of natural biological controls, or reduce the total amount of materials released into the environment?**

  The substance is made from renewable materials in the form of animal manures and crop wastes. They can increase the efficiency of use since large volumes of manure and compost do not have to be hauled from their source to farms. Ammonia extracts are concentrated and thus much easier to haul and handle.

  Ammonia extracts can be applied when needed and only in the amounts needed at that point in time by the crop. Arguments are made both ways as to whether the applications of these materials and their ready availability to plants reduces their leaching potential (since only the amounts needed can be applied) or whether they bypass soil systems that tie up and release soil nitrogen dynamically (those systems only have a small proportion of nitrogen available to leach). The timing of nitrogen application can be controlled with ammonia extracts and they can be applied in quantities that the crop needs at that point. This could lead to a better match of nitrogen added to nitrogen needed by the crop. However, there is also evidence that dynamic soil systems that release and then reabsorb nitrogen can supply crop needs while minimizing free nitrogen (Bowles, Hollander, 2015). The free nitrogen would be limited and thus leaching potential reduced.

One researcher (Phelan, Mason, et al., 1995) has conducted studies showing that plants are more resistant to insect damage when organic fertilizers are used, as opposed to readily available mineral materials. Thus, the use of ammonia extracts (or sodium nitrate for that matter), since they are readily available, can disrupt biological controls.

- **Does use of the substance have a positive influence on the health, natural behavior, and welfare of livestock?**

  N/A

- **Does the substance satisfy expectations of organic consumers regarding the authenticity and integrity of organic products?**

  While the answer to this question is not referenced in the TR or other research reports, one public commenter noted that:

  > Objections to the compatibility of these substances with organic principles are serious enough to potentially lead to fragmentation of the organic market. Some companies have indicated they may be prepared to establish private standards that exclude products produced with this input from their supply chain. This is an indication that the substance could fail to align with the 2004 NOSB Recommendation which asks NOSB to consider whether the substance would "satisfy expectations of organic consumers regarding the authenticity and integrity of organic products."

- **Does the substance allow for an increase in the long-term viability of organic farm operations?**

  This is a complex question. Some commenters argue that the potential for yield increases, precision application of nitrogen, and reduction of environmental contamination from excess nitrogen or phosphorous from composts and manures will increase long-term viability of organic farms.

  Others argue that the use of ammonia extracts will degrade soil biological systems and interfere with biological processes that are important to plant and soil health. The use of these extracts may give short term yield increases but are not promoting long term carbon building of the soil. Thus, long-term resiliency and viability may be hurt by the use of these materials.

  Using OFPA and deploying a total systems approach is necessary. Precision technology is independent of ammonia extract and should be adopted by organic farmers that are interested in increasing their yields and applying the right nutrients in the right places. Excess nitrogen or phosphorus applications need to be currently regulated through soil samples, removal rates, etc., and should not be an issue if the total systems approach is applied. Also, if there are nutrient management problems on a particular soil, avoiding solving them and bypassing them with a material that mimics conventional materials should not be permitted in an organic system. At a minimum, ammonia extracts should be listed as a restriction on the OMRI certificate that they cannot be applied if work has not been done to remediate excess phosphorus or calcium build up in soils due to over applications in prior years.

- **Is there evidence that the substance is mined, manufactured, or produced through reliance on child labor or violations of applicable national labor regulations?**

  There is no evidence that these materials violate labor regulations.

- **If the substance is already on the National List, is the proposed use of the substance consistent with other listed uses of the substance?**

  N/A

- **Is the use of the substance consistent with other substances historically allowed or disallowed in organic production and handling?**

  This is a petition to prohibit a natural material. There are other materials currently used in organic production (liquid fish, soy protein hydrolysate, sodium nitrate) that are similar in use. Of these, only sodium nitrate has significant nitrogen in an immediately plant usable form. Sodium nitrate is annotated on the National List to a limit of not more than 20% of crop needs. It is an allowed alternative to ammonia extracts. It should be noted, however, that a previous NOSB voted to prohibit use of sodium nitrate due to concerns of salt buildup and similar concerns regarding soil biology effects.

  In general, natural substances allowed in organic production are made up of complex chemical structures including lignins, proteins, carbon, nitrogen and other minerals and materials. Ammonia extracts produced through the concentration method may be similar to these historically allowed substances except that the ammonia content is concentrated and substantially higher than these naturally occurring substances. That concentration may cause these ammonia extracts to behave differently these other traditional natural materials. As noted above, that different behavior in the soil may be beneficial or detrimental. These differences may be exhibited by the differing C:N ration between ammonia extracts and other organic inputs. With the exception of sodium nitrate, most other traditional non-synthetic organic fertilizers have ratios of at least 3:1 and often greater. The low C:N ratio of ammonia extracts would be expected to cause different soil effects than those materials with higher carbon amounts.

  Proponents for the use of ammonia extracts argue that they are similar to other substances allowed and that they are only more immediately available. When used in moderate quantities they enhance soil biology and can cause soil and plant ecosystems to be more productive.

  Opponents argue that ammonia extracts bypass and short circuit soil biological processes and do not enhance long term carbon build up in the soil. Their low C:N ration is contrary to the original intent of the organic regulations in that soil fertility methods should promote long term soil health and ecosystem stability.

- **Would approval of the substance be consistent with international organic regulations and guidelines, including Codex?**

As noted in the TR, there are a number of ammonia materials listed for use in handling, but there are no listings regarding the use of ammonia extracts for crop production. The use of sodium nitrate for products exported to Canada is limited. Since ammonia extracts and sodium nitrate are similar in plant availability and solubility, it is possible that the use of ammonia extracts in products destined for Canada could also be restricted, but this is unknown at this point. Furthermore, Europe and Canada have systems of closed positive lists, meaning a material cannot be used unless it is on the allowed list. This contrasts with the United States where a non-synthetic material can automatically be used unless it is prohibited or annotated. If ammonia extracts do not appear on the Canadian or European lists, then growers in those countries are unable to use them.

Inconsistencies between international certifiers reduces export market potential and creates additional confusion with countries that have substantially different standards that the United States receives imports from.

- **Is there adequate information about the substance to make a reasonable determination on the substance's compliance with each of the other applicable criteria? If adequate information has not been provided, does an abundance of caution warrant rejection of the substance?**

Given the conflicting information regarding ammonia extracts, it seems prudent to prohibit the use of extracts. These materials have only been developed in the last ten years and there is not adequate research that would demonstrate that these high nitrogen, carbon limited materials comply with OFPA criteria for the maintenance and increase of soil organic matter. As noted above, arguments can be made that these materials have a positive effect or a negative effect. Given that there is no clear answer and that negative effects on soil health have been documented, an abundance of caution warrants a prohibition of these extracts. If future research conclusively demonstrates that these materials comply with the OFPA criteria to maintain and build soil organic matter, a petition could be submitted to remove the prohibition. Additionally, the prohibition could be allowed to expire during future sunset reviews.

Furthermore, an abundance of caution warrants a close look at the use of low (below 3:1) C:N ratio materials, such as ammonia extracts, for organic fertility. The NOSB has set precedents to the limitation of these types of materials. Sodium nitrate is limited to 20% of crop needs. Other highly soluble, non-nitrogen materials are also limited by annotation. It was noted in public comments that:

> In the preamble to the publication of the NOP Final Rule on December 21, 2000, NOP discusses how it decided to agree with the NOSB recommendation and to put specific regulation of substances of high solubility into the annotations for each of these materials where they appear on the National List of Allowed and Prohibited Substances. NOP goes on to say, "Based on the recommendation of the NOSB, the final rule would prohibit use of these materials [substances of high solubility], unless the NOSB developed recommendations on conditions for their use and the Secretary added them to the National List." At the time, the discussion was about mined substances of high solubility because there were no concentrated, highly soluble plant nutrient materials other than mined sources available at that time.

Another commenter in favor of the use of ammonia extracts stated:

> I also believe that there should be a limit on the amount or percent of AE Nitrogen applied to the crop where no more than 20 – 30% of a crops total N comes from an AE or any high Nitrogen product that contains less than a C:N ratio of 2.

This long-time concern for the use of highly soluble plant nutrients and the criteria of "an abundance of caution" is an important aspect of this petition. With respect to this petition, several options are open to the NOSB. The first is to prohibit ammonia extracts that meet the proposed definition. The second is to reject the petition altogether and allow any use of non-synthetic ammonia extracts. The third would be to annotate the use of these extracts to some maximum percent of crop needs, similar to sodium nitrate.

If an annotation to limit the use of ammonia extracts were to be put in place, the potential exists for sodium nitrate and ammonia extracts to both be used up to each of their maximum allowed rates. This stacked rate would allow for the use of higher applications than either alone. The combined use would put the burden on certifiers to identify whether the total use of these highly soluble products violated the OFPA criteria to maintain or build soil organic matter. It is likely that different certifiers would have different interpretations and that notices of non-compliance would be difficult to enforce.

Additionally, the effectiveness of a prohibition or limitation is dependent on an exact definition of ammonia extracts. If new products are developed that fall outside the definition, a future petition would have to be submitted to determine if they should or should not be allowed. This could create additional work loads and a perpetual cycle of review for each new product produced. It would seem prudent to set an additional limitation for these extracts that might fall outside the current definition, as well as for other highly soluble nitrogen materials. A limitation that would restrict the total use of highly soluble nitrogen fertilizers would prevent the "stacking" of multiple highly soluble fertilizer types. The NOSB should not have to be continually concerned about the introduction of different novel ammonia extracts or other novel non-synthetic nitrogen materials before a petition is submitted to restrict them.

Sodium nitrate was prohibited in part for this same rationale. As stated by NOSB in a past review to justify its recommendation to prohibit, the "use and dependence on sodium nitrate also can tend for producers to put off the need for strong soil-building practices, consistent with §205.203, since it behaves similarly to conventional synthetic nitrogen fertilizers." This is evidence that the substance could fail to align with the 2004 NOSB Recommendation which asks NOSB to consider whether "use of the substance is consistent with other substances historically allowed or disallowed in organic production and handling." Highly soluble sources of nitrogen cannot be addressed in a vacuum, and we cannot look at one material at a time. We must take a broader approach to limiting highly soluble sources of nitrogen as a whole. To evaluate and list each individually, even with a restriction, is a slippery slope and raises the concern of "stacking".

- **Does use of the substance have a positive impact on biodiversity**?

  Some commenters argue that ammonia extracts enhance soil biological processes, many others argue that these materials either do not impact or decrease biodiversity. A proponent of the use of ammonia extracts cited Jerry Hatfield in that:

> Bio-based fertilizers been shown to increase the characteristics related to soil health, e.g., organic matter, soil aggregates, enhanced biological activity, increased nutrient cycling because they stimulate biological activity through a balanced carbon:nitrogen (C:N) ratio

Contrarily, the 2020 TR states:

> While bioavailable nitrogen is also important for the function of microorganisms, high concentrations of ammonia and ammonium compounds result in changes to the native soil communities. These changes vary based on the initial soil communities and may result in either an increase or decrease in total population. However, while there are cases of population growth in some communities, the application of nitrogen fertilizers is associated with decreases to the diversity of these microbial communities

Given the conflicting information regarding biodiversity impacts, it would be very difficult to state unequivocally that the use of ammonia extracts has a positive impact on biodiversity. While there is a chance that these extracts do increase diversity, there is a very likely chance that they decrease biodiversity.

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The following are to be added at § 205.602 – non-synthetic substances prohibited for use in organic crop production as a new subsection , (j) ammonia fertilizers. Each type of ammonia fertilizer would be a separate subsection under ammonia fertilizers. For example:

§205.602
- (j) ammonia fertilizers
  - (i) Stripped ammonia
  - (ii) Concentrated ammonia

Stripped ammonia is intended to encompass a wide variation of novel thermo-mechanical derivations of steam stripping technology that result in ammonia-containing condensate, aqua ammonia, ammonium-compound solutions, or any products thereof, such as further isolation of ammonium compounds into a solid by precipitation or solvent evaporation, and/or treatment with nitrifying bacteria.

Concentrated ammonia is intended to focus on products with substantial levels of Am N and avoids products with minimal N. The limit on % ammoniacal nitrogen (greater than 3%) aligns with the OMRI category description for "Fertilizers with High Ammoniacal Nitrogen." If both definitions are passed, the NOP could combine them into a single listing during rulemaking.

Classification Motion:
Motion to classify ammonia extracts as nonsynthetic
Motion by: Steve Ela
Seconded by: Jerry D'Amore
Yes: 8 No: 0 Abstain: 0 Absent: 0 Recuse: 0

National List Motions:
Motion to add at §205.602, non-synthetic substances prohibited for use in organic crop production: Stripped Ammonia – created by separating, isolating and/or capturing ammonia or ammonium from an agricultural feedstock or other natural source using methods such as, but not limited to, steam stripping, pressurized air, heat, condensation, and/or distillation.

Motion by: Steve Ela
Seconded by: Jerry D'Amore
Yes: 8 No: 0 Abstain: 0 Absent: 0 Recuse: 0

Motion to add at §205.602, non-synthetic substances prohibited for use in organic crop production: Concentrated Ammonia – contains greater than 3% ammoniacal nitrogen and the total nitrogen content is predominately (i.e., >50%) in the ammonia or ammonium form.

Motion by: Steve Ela
Seconded by: Asa Bradman
Yes: 7 No: 1 Abstain: 0 Absent: 0 Recuse: 0

Motion to add at §205.203(f): Nitrogen products with a C:N ratio of 3:1 or less, including those that are components of a blended fertilizer formulation, are limited to a cumulative total use of 20% of crop needs.

Motion by: Steve Ela
Seconded by: Logan Petrey
Yes: 7 No: 1 Abstain: 0 Absent: 0 Recuse: 0

Approved by Rick Greenwood, Crop Subcommittee Chair, to transmit to NOP August 13, 2021.