National Organic Standards Board
Crops Subcommittee Proposal
Highly Soluble Nitrogen Fertilizers
January 18, 2022

Note: References are made to the 2020 Technical Report (TR) throughout this document. 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 complete list of references, please refer to the TR.

References to ammonia or ammonium are specifically intended to include both unless stated explicitly that it is only one or the other.

Use

Highly soluble nitrogen sources such as sodium nitrate, guano, and the recently reviewed ammonia extracts are used as nitrogen sources to produce a wide range of annual and perennial crops. Of these materials, sodium nitrate and guano have historically been used for organic agriculture. Sodium nitrate is on the prohibited section of the National List but is annotated to allow use to no more than 20% of crop needs. Other organic materials such as protein hydrolysates, feather meals, blood meals, and liquid fish fertilizers also provide rapid nitrogen availability to crops. A primary difference in these materials is that they are mostly protein or amino acid-based compared to materials containing primarily ammonia or nitrates. Thus, these biologically derived products require soil conversion from amino acids or proteins to ammonia and nitrates before they are plant available.

More recently, non-synthetic processes to produce highly soluble fertilizers have been developed. The recent NOSB vote to prohibit ammonia extracts is an example of when a new material, meeting the organic definition of naturally derived, enters the organic marketplace without a review process as to whether the material complies with OFPA criteria. Future processes will likely be developed for new, highly soluble nitrogen fertilizers. Therefore, it is critical that restrictions on the use of these materials occur before they can be reviewed and become widely used. If, after review, the NOSB determines that the use of a particular material falls within organic production standards, that material could be exempted from any restriction on the National List and allowed for use.

Nitrogen is often a major limitation to crop yields and is biologically vital as a macronutrient. It contributes to plant growth by forming amino acids, serves as the building block for proteins, and improves photosynthetic efficiency (2020 TR). However, as was determined with ammonia extracts, the use of highly soluble nitrogen fertilizers may not be compatible with organic production. In the past, the NOSB and those responsible for developing the USDA organic guidelines have restricted or prohibited materials of high solubility. These materials include calcium chloride, potassium chloride, sodium nitrate, and, more recently, ammonia extracts. 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 the 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 not concentrated, highly soluble plant nutrient materials other than mined sources available at that time. However, the same rationale would apply to newly developed nitrogen fertilizers of high solubility.

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 (2020 TR). Given recent developments in novel technologies, it seems likely that other non-synthetic nitrogen fertilizers could be developed similarly to ammonia extracts. Other historically used organic materials such as sodium nitrate and guano are mined from naturally occurring deposits. Protein and amino acid-based materials such as hydrolysates, fish emulsions, feather meal, and blood meal are produced from by-products of other manufacturing processes. They are allowed for use in organic production.

International
While highly soluble nitrogen products are not addressed as a group, 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 and Fall 2021 NOSB meetings voiced concerns that the use of ammonia extracts or other new highly soluble nitrogen materials in the United States might also be rejected by other countries for exported products.

Summary of Review
The reviews of non-protein/amino acid highly soluble nitrogen materials have resulted in a wide variety of public comments and perspectives. These comments were often focused on reviews of sodium nitrate and ammonia extracts. These perspectives ranged from issues with soil health and environmental concerns and the use of multiple sources of highly soluble nitrogen fertilizers (HSN fertilizers). Comments were submitted that argued for both pros and cons on each issue.

In general, the comments from long-time organic organizations and growers tended to favor limiting HSN fertilizers 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 ratios and the high solubility of these materials could cause environmental issues.

Proponents cite the need for immediately available nitrogen sources as a bridge for 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 using these materials can help prevent nitrogen loss since they could allow better targeting of nitrogen applications to specific crop needs.

As noted previously, several materials are already in the organic marketplace. These materials have been approved by OMRI and other material review organizations, although with the caveat that non-synthetic, liquid fertilizers that have a nitrogen analysis greater than 3 percent must comply with additional recordkeeping and inspection requirements following NOP Guidance on the Approval of Liquid Fertilizers for Use 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." The NOSB determined at the Fall 2021 meeting that ammonia extracts did not meet the criteria for use in an organic system plan and subsequently voted to prohibit ammonia extracts in organic production.

Furthermore, the Board and other stakeholders expressed concerns that new, non-synthetic HSN fertilizers that fall outside the definitions of ammonia extracts could be developed in the future. Those materials would have no limit to their use unless a petition to restrict or prohibit them was submitted to the NOSB and the NOSB voted to restrict their use.. The use of new non-synthetic fertilizers might have similar issues to ammonia extracts with regard to compatibility with organic systems. Thus, the NOSB proposes that limitations be put on any HSN fertilizer until the NOSB can review it, and if so desired, a developer of a new HSN fertilizer could petition the NOSB to remove the restriction. Manufacturers would also know of potential limitations before investing in novel production methods for these fertilizers.

Soil Health

The Organic Foods Production Act (OFPA) through 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), OFPA states that the producer must manage plant and animal materials or crop nutrients and soil fertility to maintain or improve soil organic matter content.

At the Fall 2020, and Spring and Fall 2021 NOSB meetings, many commenters noted that the use of HSN fertilizers runs counter to the organic principles outlined in the regulations by directly applying plant nutrients rather than applying nutrients that improve the biological condition of the soil. Inherently, the annotation added to high nitrogen (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. For example, several commenters testifying in favor of ammonia extracts at the 2020 and 2021 NOSB meetings reinforced this by stating that these ammonia extracts should not be used alone – they 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 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 agro-ecosystems. Biodiversity promotes balance, which protects farms from damaging insects and disease outbreaks. 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, genuinely organic farms produce healthy plants that require far fewer applications of insecticides and fungicides (even if approved for organic production).

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—non-synthetic 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 the 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.

The current motion to restrict the use of highly soluble nitrogen fertilizers follows this recommendation to prohibit or limit the uses of highly soluble materials unless the NOSB develops recommendations and conditions for their use. The motion would prevent the widespread use of new, non-synthetic fertilizers while also allowing for the potential of restricted use of these materials in critical situations. Some of those situations were outlined in the ammonia extract proposal. These include times when abnormal weather events cause temporary nitrogen deficiencies or limited situations where the release rate of appropriately applied organic inputs does not meet crop needs.

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 (Sharif, Thompson, et al., 2021; Ozlu, Sandhu, et al., 2019). Living organisms' total amounts (weights) 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 use other organic materials such as cover crops, animal manures, and composts. When crops are rotated regularly, fewer parasites, diseases, weeds, and insect problems occur than when the same crop is grown year after year (Magdoff and Van Es, 2021). These biotic links can also positively influence the ability of plants to resist insect pests. Plants grown in a balanced nutrient system are less likely to be attacked by pests than plants with readily available nitrogen added (Phelan, Mason, et al., 1995).

The NOSB received comments that HSN fertilizers may increase the mineralization rate in soils and thus be beneficial. This could be true in a short time frame, but this accelerated mineralization rate 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 more significant nitrogen loss over time. Essentially, adding more nitrogen fertilizer results in long-term nitrogen loss 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, the 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 agro-ecosystems. The reductions in nitrate loss in this study could also be achievable in other studies cropping systems (Kramer, Reganold, et al., 2006).

Organic systems include cover cropping and interplanting and varied crops and the addition of manures and composts. This mix of fertility sources is used to mitigate issues of nutrient excesses.

> Incorporating **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 more effectively retain cations, 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 the soil health, plant health, and biological interactions need to be conducted. There is conflicting information from 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 and between fields within a farm. Most research-oriented toward nitrogen cycling occurs at research stations with fixed factors and limited soil variations; there has been little research about how nitrogen cycling happens 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 that our lack of understanding of nutrient processes and needs in organic systems makes conclusions about the need for fast-acting nitrogen applications problematic.

These factors make reaching a conclusion difficult. In the absence of consistent research showing overwhelming benefits from the high applications of HSN fertilizers, and with the requirement to fulfill OFPA criteria, the use of these 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 using multiple approaches to fertility that include the basics of crop rotations and applications of manures and composts. By paying attention, these systems do not result in large build-ups of phosphorous or excessive loss of nitrogen to the environment. There are arguments for the limited use of allowed HSN fertilizers in emergency situations or when soil availability of nitrogen is limited. However, there are strong arguments that the use of these materials should be limited. The ecosystem managed to maintain or increase soil organic matter does not include reliance on a highly soluble fertilizer.

While organic regulations require an organic soil fertility plan to maintain or improve soil organic matter (205.203), the interpretation of this requirement can be complicated 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 challenging to have a notice of non-compliance from a certifier be enforceable. A prohibition with an annotation allowing restricted use of HSN fertilizers would give certifiers an additional tool to interpret growing practices that comply or do not comply with OFPA.

The restriction of the use of sodium nitrate to 20% of crop needs from the beginning of the National Organic Program limits the potential for overuse of that form of highly soluble nitrogen fertilizers. The prior vote of the NOSB to completely prohibit ammonia extracts illustrates the concern the organic community has for using these highly soluble 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 kinds 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. Two major liquid nitrogen products are made with liquid fish (fish solubles, fish protein, fish emulsion, hydrolyzed fish) and 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. At what point does the use of highly soluble nitrogen fertilizers cross the line to being the primary source of nitrogen, with other soil organic building practices being a minor part of the fertility program?

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

> Many substances derived from natural products 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
Cottonseed	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 applied over 40:1 can cause temporary plant nitrogen deficits since nitrogen must be taken from surrounding soil to break down 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 synthetic nitrogen fertilizers' chemistry and functionality can be considered equally incompatible with traditional organic principles.

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 below a 3:1 ratio tend to be those that are immediately plant available.

Public comments received during the Fall 2021 NOSB meeting raised several concerns regarding the motion to restrict nitrogen fertilizers with a C: N ratio of 3:1 or less, including those individual components of a blended fertilizer formulation, to a cumulative total use of 20% of crop needs.
As always, stakeholder insights are a welcome part of NOSB decision-making. A number of certifiers submitted comments at the Fall 2021 meeting supporting the motion as written. However, others had concerns and asked for further vetting of the motion. The following address specific comments raised by stakeholders.

Clarifying which nitrogen materials might be covered – the proposal initially read "Nitrogen products." Since this could cover any material with nitrogen incorporated in it, the phrasing has been changed to read "Nitrogen fertilizers." This specifies materials used to fertilize crops rather than any nitrogen compound and follows the definition of fertilizers listed in the organic regulations.

Clarification as to how fertilizer blends are evaluated – Some commenters suggested that the final product's overall C: N ratio is used rather than looking at individual components of a blend. While this would simplify the evaluation, it would sidestep the intention of the motion. For example, a high carbon source could be mixed with an HSN composed entirely of nitrate to bring the blend above the required 3:1 ratio. However, that blend would still be mainly composed of a nitrogen fertilizer that is immediately plant available. Carbon would be added to the soil, but the nitrogen component would bypass important nitrogen cycling soil processes described previously. While some fertilizers include some nitrate or ammonia (such as liquid fish), the preponderance of nitrogen is not ammonia or nitrate (see chart previously cited). Likewise, to support soil biological processes, a blended fertilizer should contain components that include soil biological processes for nitrogen release.

To determine the amount of nitrogen in a blend that would be included in the restriction, the percentage of the nitrogen in a multi-component product (blend) that is below the 3:1 ratio can be calculated.

In order to know what percent of the nitrogen in a blend counts toward the 3:1 restriction, a manufacturer could either provide the percent of the nitrogen in the blend that is restricted on the label (without disclosing what that material is) or a Material Review Organization could list that on the product certificate. As a last resort, if neither of those listings is available, the grower could call the manufacturer for that information. This would be similar to the soluble and insoluble nitrogen sub-analysis that is already present on fertilizer labels, i.e., 3% N from ingredients below 3:1 C: N. If a grower uses multiple fertility sources, they will total all the N application from restricted materials and make sure the total is less than 20% of the crop needs.

If manufacturers won't disclose the information, one certifier notes:

> When people say manufacturers won't disclose, with pesticide materials it is the same way. If you won't tell us, we won't approve it. Besides, saying 20% of a blend is below 3:1 doesn't say anything about what the actual materials are that make up that 20%. Things can still be confidential. I think many of these materials will go through an MRO anyhow and they can just list the C: N ratio on their listing, or at least whether it is above or below 3:1. And, it may push

people to use less of these highly soluble materials since it will be very transparent as to what they use.

The process to identify the total nitrogen in a blend that is restricted is as follows:

1. What is the source of the material?
2. Does the HSN Fertilizer contain multiple components (blend)?
    a. NOTE: Make sure to determine the source of all the material(s) within a product
3. What is the C:N ratio of the components(s)?
4. Does any of the components(s) of the fertilizer fall below the 3:1 C: N ratio
    a. If no, then the fertilizer (and its respective components) has no restrictions
    b. If yes, then component(s) of the fertilizer needs to be analyzed, and a nitrogen calculation needs to be conducted to quantify pounds of N from a restricted source.
5. Obtain the %nitrogen of the product and the %nitrogen that is restricted from the material(s) that fertilizer product is composed of from the manufacturer, MRO, product certificate, or product label
6. Based on the overall Nitrogen composition – determine how many pounds of N would be restricted from the known concentration of HSN that is restricted due to falling below the 3:1 ratio in relation to the entire product
7. Identify what 20% of crop needs are and ensure that restricted material(s) fall below that level.

An example:

- If a product containing multiple components (a blend) contains a material that would be restricted (below a 3:1 ratio) and that material provides 50% of the nitrogen in the overall product, then 50% of the amount of nitrogen in the fertilizer would fall under the HSN fertilizer restriction.

- If the blended product was an 8-0-0 and a producer applied 100 lbs., then 8 lbs. of actual N would be applied to the crop.

- Since 50% of the nitrogen in the blended product falls under the restriction, therefore in this example, 4 lbs. of the actual N being applied would count towards the overall limit of 20% of crop needs.

- If the total crop need is 80 lbs. of nitrogen, then up to 16 lbs. of that N could come from a restricted material(s) (20%*80lbs = 16lbs).

- If the blend is the only fertilizer applied, then up to 400 lbs. of the blend could be used.

Additional Examples:

Example Fertilizer	Source	Blend?	C:N ratio	Contains restricted material?	Total %N of product (provided by manufacturer)	%N from restricted N material (provided by manufacturer or MRO)	%N in total product restricted (total N x % of total N restricted)	Amount restricted N per 100 lb of product applied	Crop N need lb/ac	20% of crop N need lbs/ac	Total lbs of actual product use allowed (assuming only this product applied)
A	sodium nitrate	No	0.2:1	Yes	16	100	16	16	100	20	125
									150	30	188
									200	40	250
B	fish emulsion	No	5:1	No	4.5	0	0	0	no restriction on use	-	-
C	poultry litter	No	10:1	No	5	0	0	0	no restriction on use	-	-
D	poultry litter	Yes	10:1	Yes	10	50	5	5	100	20	400
	sodium nitrate		0.2:1						150	30	600
									200	40	800
E	poultry litter	Yes	10:1	Yes	13	30	3.9	3.9	100	20	513
	feather meal		3.6:1						150	30	769
	sodium nitrate		0.2:1						200	40	1026

Determination of total crop nitrogen needs – this approach is consistent with the sodium nitrate listing. The limitation of use to 20% of total crop needs parallels the sodium nitrate wording. It prevents conflicting interpretations of how this listing and the sodium nitrate listing would apply to each other. Certifiers also evaluated the 20% of total crop needs for sodium nitrate for twelve years before that listing became technically incorrect. While several certifiers have stated that they had difficulty with those calculations, they were still enforced. Guidelines could be developed with crop needs that all certifiers could use. If a producer argued that the figure was too low, they could present soil analyses, production data, or other means to support their higher crop needs.

Crop nitrogen needs are widely available from university extension publications on a state and regional basis. For example, the University of Georgia College of Agricultural Sciences has a publication available on the internet showing N crop needs: http://aesl.ces.uga.edu/publications/soil/cropsheets.pdf It shows canola as needing 135-175 lbs. of nitrogen per year. Thus, up to 27- 35 lbs. (actual N) of fertilizer below a 3:1 C: N ratio could be applied per year.

Recommendations:

Recommended pH:	6.0. If the pH is less than 6.0, see Lime Table C.
Nitrogen:	135-175 pounds nitrogen (N) per acre. Rate will depend upon cropping system.
Magnesium:	If soil test Mg level is low and lime is recommended, use dolomitic limestone; if soil test Mg is low and lime is not recommended, apply 25 pounds of Mg/Acre.
Other:	See sulfur (S) and boron (B) recommendations below.

Coastal Plain	Low: 0 - 60 lbs/acre	Medium: 61 - 120 lbs/acre	High: >120 lbs/acre
Piedmont	Low: 0 - 120 lbs/acre	Medium: 121 - 240 lbs/acre	High: >240 lbs/acre

Fact Sheet:

*For canola following a non-legume crop, apply 160 to 175 pounds nitrogen (N) per acre. Following a legume crop, apply 135 to 150 pounds nitrogen per acre. Apply 40 to 50 pounds of the recommended nitrogen per acre in the fall and the remainder in early February prior to crop bolt (rapid stem elongation).

The Supplemental Technical Report on sodium nitrate (2011) includes an example chart with nitrogen requirements for select organic crops in the Midwestern United States:

Table 1: Per Acre Applications of Nitrogen Required for Select Crops Grown on Organic Farms in the Midwestern United States

Crop	**Amount of N Required lbs./acre)**	**Maximum NOP Allowed 20% of Requirement (lbs./acre)**	**Projected Amount of Chilean Nitrate 16-0-0**1 **(lbs./acre)**
Winter wheat	80-100	16-20	100-130
Spring wheat	80-100	16-20	100-130
Oats, barley, spelt	60-80	12-16	75-100
Corn	120-150	24-30	150-180
Sweet corn	80-100	16-20	100-130
Pasture-grass	100-120	20-24	120-150
Soybean	8-15	1.5-3	10-20
Alfalfa-low OM soil	8-10	1.5-2	10-12
Cotton	50-75	10-15	60-100
Peanuts	80-120	16-20	100-130
Potatoes	180-200	36-40	225-250
Cole Crops	150-175	24-35	150-200
Green Beans	60-80	12-16	75-100
Cucurbit	100-150	20-30	120-180
Onions, Leeks, Garlic	100-150	20-30	120-180
Tomatoes	100-150	20-30	120-180
Carrots	100-150	16-20	120-180

Finally, a common source of crop nitrogen needs is those listed in soil analyses. Recommendations from labs doing those soil tests are a readily available reference source of accepted crop needs.

Traditional organic fertilizers that might be affected by the 3:1 ratio – Stakeholders raised concerns that several organic fertilizers traditionally used by producers might fall just below the 3:1 ratio. As noted in the table previously listed, feather, bone, and blood meals are above the 3:1 ratio but are very close. Certifiers or material review organizations could develop a list of unrestricted, allowed materials, such as these, that could be referenced so that they would not need to be continually reanalyzed. Several commenters suggested developing a closed list of materials that would fall below the 3:1 ratio and specifically state they could not be used. However, one concern is that new, not identified materials will be introduced. The purpose of this motion is to limit the use of new, novel nitrogen sources. Specifically stating what materials would be limited by this proposal would not limit new, currently unidentified products. If, for example, manufacturers develop products that are not covered under the specifics of the ammonia extract prohibition, this motion would limit the use of those products falling outside those definitions. A manufacturer could submit a petition for unrestricted use if they wanted their product to be exempt from this restriction. While creating a closed list of products below a 3:1 ratio would defeat the purpose of this motion, making a list of what known materials (feather meal, bone meals) are recognized as being **above** the 3:1 ratio might be useful.

Clarification of why the C: N ratio is used rather than total fertilizer N or percentage of ammonia/nitrate to total N – existing fertilizers commonly used in organic production have widely varying amounts of ammonia/nitrate to total N ratios. Given this range, it is difficult to determine where a material would be acceptable in terms of ammonia/nitrate to total N ratio. The motion could read that, materials with greater than 50% of ammonia/nitrate compared to total N would be restricted. But then there would be an incentive to make a material that included only 49% of these HSN fertilizers. In addition, fertilizers that contain proteins require soil mineralization to become plant available. These materials inherently contain carbon to form proteins. Using a C: N ratio addresses the need to have carbon-based materials applied to soil to promote the soil biology and transformation processes rather than only applying plant-available nitrogen fertilizers composed of nitrate or ammonia.

Clarification on listing – Several commenters raised the question of whether § 205.203(f) is the correct place to put this motion. Ultimately, where this motion would be listed would be determined by the NOP. This motion intends that this limitation of HSN fertilizers apply to all crop producers, regardless of production system. This is similar to how synthetic materials added to the National List are allowed for all crop producers. Thus, the motion could be placed at § 205.602, similar to the prohibition on sodium nitrate or the suggested listing of ammonia extracts. Materials with a C: N ratio below 3:1 would be prohibited, but with an annotation allowing up to 20% of crop needs, similar to sodium nitrate. The listing could also be placed in the practice standards at § 205.105 or § 205.203(e) – "the producer must not use." This would be like the practice standard of prohibiting the use of sewage sludge or materials that contain synthetic substances not included on the National List. The final placing of the listing by the NOP should ensure that it applies equally to all producers of food crops like the materials placed at § 205.602 or § 205.105. Other motions approved by the NOSB and passed through rulemaking have had similar intent in uniform applicability.

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.

Highly soluble nitrogen fertilizers can be manufactured using non-synthetic processes, as demonstrated by the development of ammonia extracts. The development of ammonia extract could not be anticipated at the time of the National Organic Program's adoption. Similarly, it is likely that there will be the development of additional, non-synthetic HSN fertilizers through novel manufacturing processes.

1. 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?

Highly soluble nitrogen fertilizers do not include any of the above materials.

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 highly soluble nitrogen fertilizers can affect soil pH and/or 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 its breakdown products or contaminants and their persistence and areas of concentration in the environment? [§6518(m)(2)]

Highly soluble nitrogen materials may have short lifetimes in the environment, typically ranging from hours to days based on environmental conditions. The short environmental lifetimes are due to the bioavailability of nitrogen in these compounds, which are readily incorporated into amino acids and other biologically important molecules.

Furthermore, the TR states that the high-water solubility of ammonia, ammonium, and nitrate ions makes them conducive to leaching into water ecosystems. While aquatic microorganisms can metabolize these compounds, 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 highly soluble nitrogen materials could result in the release of nitrogen into the environment. This is expected due to the inability of processes to capture 100% of the nitrogen content of feedstocks. The efficiency of capture depends on the processes used (2020 TR).

The release of these compounds into the atmosphere can contribute to the degradation of air quality and visibility due to the formation of 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 may be used to produce these compounds will depend on the processes. 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 feedstock is disposed of after removing nitrogen.

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

The 2020 TR refers to several human health effects from highly soluble nitrogen materials such as ammonia. Ammonium is a positive ion, and its impact on human health depends 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 agro ecosystem, 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: Highly soluble nitrogen compounds can readily migrate from the applied soil system into the atmosphere and marine environments. When these materials remain in their applied soils, they can also induce changes to the local environment. For example, 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 crops and soil organisms. Changes in soil pH may also negatively impact the viability of soil organisms, including earthworms and various microbial populations. High soil concentrations of inorganic nitrogen sources have been shown to slow the natural nitrogen fixation processes of plants. This shift in natural nitrogen production reduces the natural efficiency of the soil, making it more reliant on continued nitrogen inputs.

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

The use of HSN fertilizers can alter nitrogen uptake rates 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). Living organisms' total amounts (weights) 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 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)

Several public comments noted that the use of HSN fertilizers 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 more significant nitrogen loss over time. Essentially, adding more nitrogen fertilizer results in long-term nitrogen loss 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, the 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 agro-ecosystems, 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 incorporating crop residues and compost provides a potential long-term alternative to HSN 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 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 HSN fertilizers. 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 manure and other organic agricultural wastes. These feedstocks' high protein and amino acid content allow 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).

Incorporating 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 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).

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 lower 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 can 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, increased CEC properties, and prevents soil erosion. However, 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?

To 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**?

During the discussion and public comment period regarding ammonia extracts at the 2020 and 2021 NOSB meetings, commenters indicated that ammonia extracts must be used with other soil-building practices to comply with OFPA criteria. These comments would suggest that the use of ammonium extracts alone does 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 provided a range of responses that either indicated that these extracts would harm soil biological properties or that they would enhance these properties.

Diverse soil fertility practices can increase soil biological activity, as noted by one comment:

> 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 crops 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, 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 HSN Fertilizer to an 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 these materials 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 HSN fertilizers 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 the management of crop, livestock, and/or handling operations?**

Commenters have argued that the limited use of HSN fertilizers 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 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 the 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 early plant germination. There can be a phosphorus deficit in the plants when cold/wet soils occur, even in excess phosphorus soils. From the viewpoint of conventional farmers, a true starter fertilizer is 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 organic soil.

Additionally, HSN fertilizers inherently contain a very low C: N ratio. In the past, the NOSB had 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. These precedents may lead to the conclusion that all HSN’s that are separated from their carbon source should be prohibited, similar to the vote by the NOSB to prohibit ammonia extracts. However, at this time, this motion mimics the annotation for sodium nitrate, allowing very limited use of an HSN.

- **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?**

Arguments are made both ways as to whether applications of HSN fertilizers and their ready availability to plants reduce 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 HSN fertilizers, 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 the nitrogen required 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, et al., 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 instead of readily available mineral materials. Thus, the use of HSN fertilizers can disrupt biological controls since they are readily available.

- **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 indicates 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 the long-term viability of organic farms.

Others argue that using HSN fertilizers will degrade soil biological systems and interfere with biological processes important to plant and soil health. Using these materials may increase short-term yield but not promote long-term soil carbon building. Thus, long-term resiliency and viability may be hurt by using these materials.

Using OFPA and deploying a total systems approach is necessary. Precision technology independent of nitrogen sources should be adopted by organic farmers interested in increasing their yields and applying the right nutrients in the right places. Excess nitrogen or phosphorus applications need to be 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, HSN fertilizers should be listed as a restriction on the OMRI certificate. 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 proposal to limit the use of non-synthetic nitrogen materials. Other materials currently used in organic production (liquid fish, soy protein hydrolysate, blood meal, sodium nitrate) are similar in use. Still, all outside of sodium nitrate is protein-based, requiring some mineralization before impact to plants. 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. When this restriction was applied, sodium nitrate was one of the very few highly soluble nitrogen materials available, and it was naturally mined and not manufactured. However, it should be noted that a previous NOSB voted to prohibit the use of sodium nitrate due to concerns of salt build-up and similar concerns regarding soil biology effects. This motion mirrored restrictions on sodium nitrate when it was one of the few non-synthetic forms of highly soluble nitrogen.

In general, natural substances allowed in organic production are made up of complex chemical structures, including lignans, proteins, carbon, nitrogen, and other minerals and materials. As noted above, different behavior in the soil of HSN fertilizers may be beneficial or detrimental. These differences may be exhibited by the differing C: N ratio between these materials and other organic inputs. Except for 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 HSN fertilizers would be expected to cause different soil effects than those materials with higher carbon amounts.

Proponents of HSN fertilizers argue that they are similar to other substances allowed and 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 HSN fertilizers bypass and short circuit soil biological processes and do not enhance long-term carbon build-up in the soil. Their low C: N ratio 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?**

The use of sodium nitrate for products exported to Canada is prohibited. Inconsistencies between international certifiers reduce export market potential and create additional confusion with countries with 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 the use of HSN fertilizers, it seems prudent to limit the usage of extracts. As with the debate regarding ammonia extracts, adequate research demonstrating that these high-nitrogen, carbon-limited materials comply with OFPA criteria for maintaining and increasing soil organic matter is very limited. As noted above, arguments can be made that these materials have a positive or negative effect. Given that there is no clear answer and adverse effects on soil health have been documented, an abundance of caution warrants a limitation on using HSN fertilizers. Since future innovations in the non-synthetic production of HSN fertilizers are possible, a limit on the cumulative use of HSN fertilizers in organic agriculture is prudent. 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 limitation.

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:

> An abundance of caution warrants a close look at the use of low (below 3:1) C: N ratio materials. The NOP and NOSB have previously discussed the need to limit materials of high solubility. Furthermore, the recent vote by the NOSB to prohibit ammonia extracts is another example of the concern over the use of these types of low C: N ratio materials.
>
> 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.

This long-time concern for using highly soluble plant nutrients and the “an abundance of caution” criteria is important for this proposal. Concerning this motion, several options are open to the NOSB. The first is to reject the motion altogether and allow the unlimited use of non-synthetic HSN fertilizers (except for the 20% limitation on sodium nitrate). The second is to annotate the use of each of these materials to some maximum percent of crop needs, like sodium nitrate. The third is to limit the cumulative total use of these materials to some maximum percent of crop needs.

If an annotation to limit the use of a single material were to be put in place, the potential exists for sodium nitrate, and another allowed HSN to both be used up to each of their maximum allowed rates. This stacked rate would allow for 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 challenging to enforce.

Additionally, the effectiveness of a prohibition or limitation is dependent on an exact definition of materials already prohibited or limited. If new products are developed that fall outside those definitions, a future petition would have to be submitted to determine if they should or should not be allowed. This could create additional workloads and a perpetual cycle of review for each new product produced. It would seem prudent to set an additional limitation for materials that might fall outside the current definitions and other highly soluble nitrogen materials.

A limitation restricting the total use of highly soluble nitrogen fertilizers would prevent the "stacking" of multiple highly soluble fertilizer types. With the proposed motion, to restrict nitrogen fertilizers with a C: N ratio of 3:1 or less, including those individual components of a blended fertilizer formulation, to a cumulative total use of 20% of crop needs, The NOSB should not have to continually be concerned about the introduction of novel non-synthetic nitrogen materials before a petition is submitted to restrict them. Manufacturers of these new HSN fertilizers would know that there is a limitation on an HSN fertilizer before resources are invested in the process. A manufacturer could also submit a petition to remove any restriction applied to their product.

A public commenter noted:

> 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. If each material must be evaluated and listed individually, the evaluation process could be endless. Additionally, there would be the possibility of stacking HSN fertilizers, thus bypassing any restrictions on individual HSN fertilizers.

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

There are arguments that HSN fertilizers enhance soil biological processes, while others say 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 have 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, regarding ammonia extracts, 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 in the diversity of these microbial communities.

Given the conflicting information regarding biodiversity impacts, it would be difficult to state unequivocally that the use of HSN fertilizers positively impacts biodiversity. While there is a chance that these materials increase diversity, there is also a very likely chance that they decrease biodiversity. As noted during the debate that eventually led to an NOSB vote to prohibit ammonia extracts, there are situations where the very limited use of highly soluble nitrogen fertilizer may be warranted. The current use of sodium nitrate or guano meets these situations. However, a limitation on the use of these materials and the use of any future HSN fertilizers prevents the potential stacking or overuse of these materials. In addition to the prohibition on ammonia extracts, this motion will limit the use of any new novel highly soluble nitrogen materials until their compliance with OFPA criteria can be evaluated through the petition process.

References

Bowles, T.M., Hollander, A. D., Steenwerth, K. L., Jackson, L. E.; 2015; Tightly-coupled plant-soil nitrogen cycling: Comparison of organic farms across an agricultural landscape. *PLoS ONE* 10(6): e0131888.

Cassity-Duffey, K., Cabrera, M., et al.; 2020; Nitrogen mineralization from organic materials and fertilizers: Predicting N release; Soil Science Society of America Journal, March/April, 84:2, p. 522-533.

Geisseler, D. A; 2014; Long-term effects of mineral fertilizers on soil microorganisms: A Review; Soil Biology & Biochemistry, 75:54-63.

Hartz, T.K., Johnstone, P.R.; Nitrogen Availability from H-nitrogen containing organic fertilizers; 2006; Horttechnology, January-March, 16:1, p. 39-42.

Hijbeek, R. M.; 2017; Do organic inputs matter - a meta-analysis of additional yield effects for arable crops in Europe; Plant Soil, 411:293-303.

Kramer, S. B, Reganold, J. P., Glover, J. D., et al.; 2006; Reduced nitrate leaching and enhanced denitrifier activity and efficiency in organically fertilized soils; Proceedings of the National Academy of Sciences 103, April p. 4522-4527.

Lazicki, P., Geisseler, D., Lloyd, M.; 2020; Nitrogen mineralization from organic amendments is variable but predictable; Journal of Environmental Quality, March/April, 49:2, p. 483-495.

Lori, M. S.; 2017; Organic farming enhances soil microbial abundance and activity - A meta-analysis and meta-regression; Plos One, 12:e0180442.

Magdoff, F., Van Es, H.; 2021; Building soils for better crops – ecological management for healthy soils; SARE Handbook Series Book 10, Fourth Edition.

Miner, G. L., Delagado, J. A., Ippolito, J. A., et al.; 2020; Assessing manure and inorganic nitrogen fertilization impacts on soil health, crop productivity, and crop quality in a continuous maize agro-ecosystem; Journal of Soil and Water Conservation, July, 75:4, p. 481-498.

Ozlu, E., Sandhu, S. S., Kumar, S., et al.; 2019; Soil health indicators impacted by long-term cattle manure and inorganic fertilizer application in a corn-soybean rotation of South Dakota; Scientific Reports, 9:1, p. 11776.

Phelan, P. L., Mason, J. F., Stinner, B. R.; 1995; Soil-fertility management and host preference by European corn borer, Ostrinia nubilalis (Hiibner), on Zea mays L.: A comparison of organic and conventional chemical farming; Agriculture, Ecosystems and Environment, 56, p. 1-8.

Sharaf, H., Thompson, A. A., Williams, M. A., et al.; 2021; Functional change in bacterial communities to fertilizer and rootstock; Soil Science Society of America Journal, July/August, 85:4, p. 1105-1121.

Wang, X., Junliang, F., Guoce, X., et al.; 2018; The Effects of Mulch and Nitrogen Fertilizer on the Soil Environment of Crop Plants; Article *in* Advances in Agronomy, Chapter 3, October.

Subcommittee Vote:

National List Motion
Motion to add at § 205.105: nitrogen fertilizers with a C: N ratio of 3:1 or less, including those individual components of a blended fertilizer formulation, are limited unless use is restricted to a cumulative total use of 20% of crop needs.
Motion by: Amy Bruch
Seconded by: Brian Caldwell
Yes: 7 No: 1 Abstain: 0 Absent: 0 Recuse: 0