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(54) **CORN STOVER BLANKET AND METHOD OF MAKING THE SAME**

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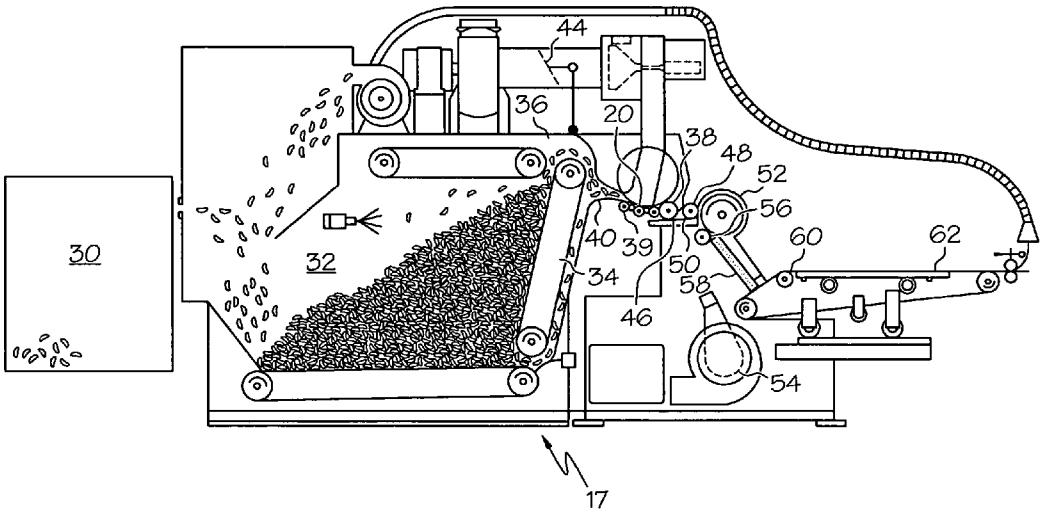
(57) **ABSTRACT**

A revegetation blanket formed from fibers, the fibers formed from corn stover and methods of making and using the same.



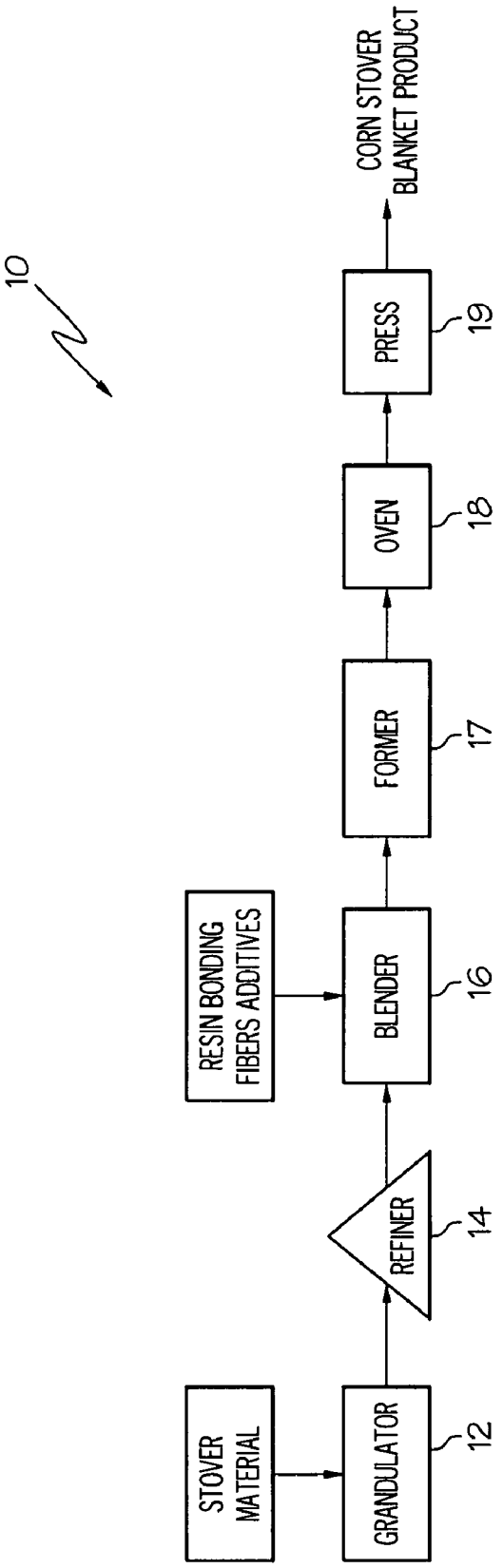

10
STOVER MATERIAL
GRANDULATOR
12
REFINER
14
RESIN BONDING FIBERS ADDITIVES
BLENDER
16
FORMER
17
OVEN
18
PRESS
19
CORN STOVER BLANKET PRODUCT

FIG. 1

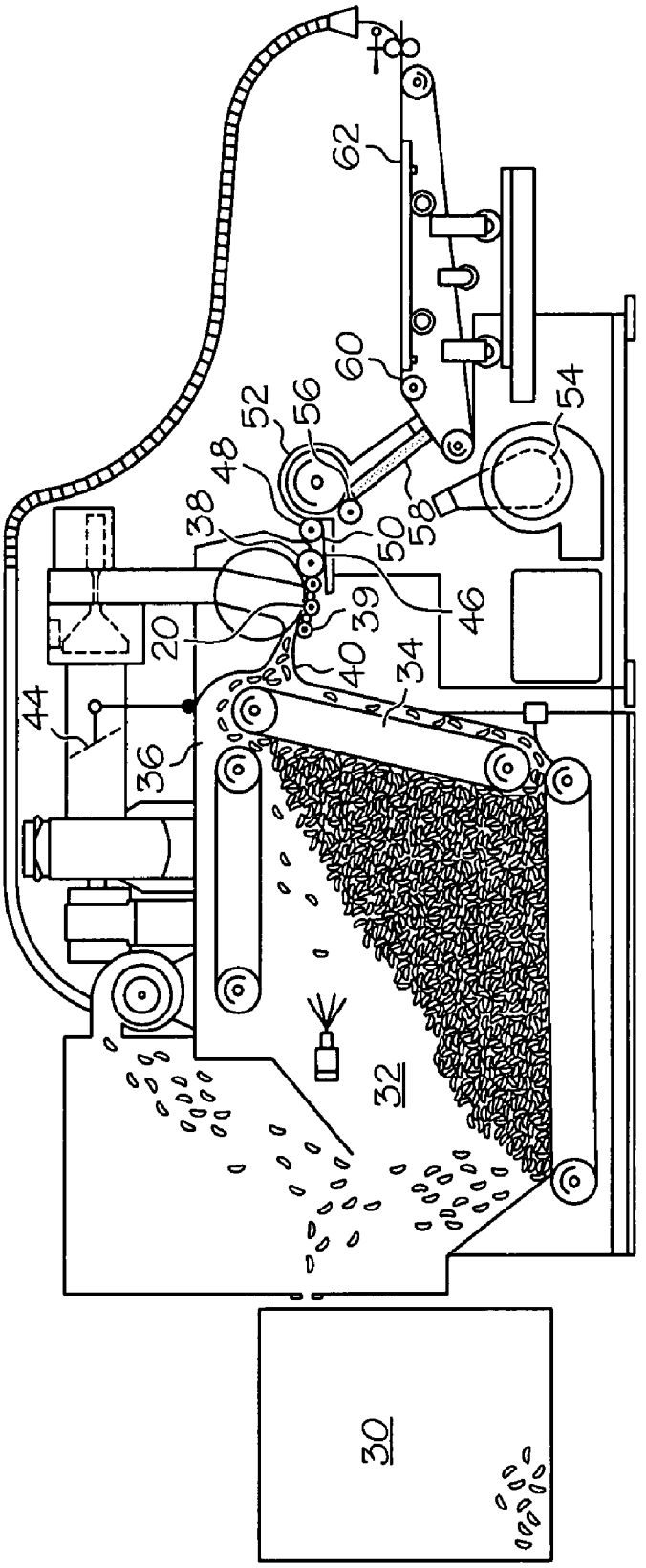


FIG. 2

CORN STOVER BLANKET AND METHOD OF MAKING THE SAME

CROSS-REFERENCE TO RELATED U.S. PATENT APPLICATIONS

[0001] This application claims priority from U.S. provisional patent application No. 60/628,731 filed Nov. 16, 2004, the entire content of which is incorporated by reference herein.

FIELD OF THE INVENTION

[0002] This invention relates to a blanket or mat made from corn stover and/or fibers made from corn stover which can be used for a variety of agricultural, landscaping, and livestock purposes, and to processes of making and using the same.

BACKGROUND OF THE INVENTION

[0003] Conventional processes for producing revegetation/erosion controlling blankets already exist. Most utilize various wood, paper, synthetic/adhesive fibers and blends thereof. The blankets are then reinforced with top-netting. Processes for producing a blanket-like mat are well known in the industry.

[0004] For example, U.S. Pat. No. 4,635,576 describes a soil erosion control blanket formed from a mat of interlocking woodwool fibres, the mat of woodwool being retained as a coherent structure by means of longitudinal rows of stitching giving the blanket a quilted appearance.

[0005] U.S. Pat. No. 4,580,960 discloses a mat product applied over soil to provide a favorable growth medium for seeds or seedlings.

[0006] U.S. Pat. No. 4,418,031 describes a moldable fibrous mat from which a product of predetermined shape can be molded by the application of heat and/or pressure. The mat consists essentially of base fibers and carrier fibers with the base fibers having a substantially higher softening temperature, if any, than the carrier fibers. The base and carrier fibers may be either virgin or reclaimed. Suitable base fibers are made of materials such, for example, as wood, jute, sisal, cotton, coconut, kapok, rayon, acetate, triacetate, paper, graphite, glass, mineral wool, and other synthetic and natural fibers. Fibers of cellulosic material maybe stressed. Wood fibers constitute an example of such a cellulosic material.

[0007] U.S. Pat. No. 4,353,946 discloses a shredded wood wool fiber mat which is retained in a coherent structure using a biodegradable plastic mesh.

[0008] U.S. Pat. No. 3,577,312 discloses a mat formation process used to form the wood fiber substrate into the inventive mat prior to thermobonding.

[0009] U.S. Pat. No. 3,010,161 describes a method of producing fibrous webs using air suspension.

[0010] U.S. Pat. No. 2,757,150 discloses a process used to produce wood fibers using "thermo-mechanical" defibration.

[0011] Corn stover is made from the corn plant, including the stalk and leaves but excludes the corn kernel, tassel and cob. Corn stover is a main waste product of the corn producing industry.

[0012] Current approaches to recycling corn waste materials are limited and usually include being chopped, spread over the field and tilled under to decompose or being processed and ensiled as silage for livestock feed. The use of corn stover as a blanketing raw material constitutes a value added product option to the grain, specifically corn, producer.

[0013] It would be beneficial to employ corn stover in a blanket product which can be used for livestock, erosion control, revegetation, potting purposes, for bare root plants, and other agricultural purposes.

SUMMARY OF THE INVENTION

[0014] The present invention relates to a corn stover blanket or mat product and to a method of making the same.

[0015] In one embodiment, the method includes the steps of corn stalk material, defibrating the corn stalk material to form stover fibers, and mixing the corn stover fibers with other optional materials such as synthetic fibers and/or other suitable natural fibers, resins, adhesives, dyes, perfumes, etc., as desired.

[0016] Optionally, a netting may be incorporated into the blanket or mat as well or the blanket/mat may be formed over a netting.

[0017] Suitably, the process herein is a dry process.

[0018] In another aspect, the present invention relates to a process for producing a blanket or mat formed with corn stover, the process including the steps of harvesting the corn stover and thermo-mechanical defibrating the corn stover.

[0019] In one embodiment, the process is a substantially dry process for forming a blanket-like product from corn stover and other fibers wherein the corn stover material or corn stover fibers never reach a moisture content greater than about 25 wt-% to about 30 wt-%. Such an embodiment therefore employs limited amounts of water relative to other processes in which a slurry of the recycled waste product is prepared.

[0020] The blanket/mat product can be formed into a continuous roll and packaged for later sale.

[0021] The blanket/mat product has desirable erosion controlling and revegetating qualities and may be formed such that it is biodegradable.

[0022] Erosion control/revegetation blankets/mats are used as a temporary ground cover over newly seeded areas of ground. The blankets/mats are unrolled and stapled or staked into place on mild slopes or flatter areas and left to degrade as the underlying seeds germinate and vegetation grows.

[0023] Other aspects of the invention are described in the Detailed Description and in the claims below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. **1** is a flow chart illustrating an embodiment of the process of making a blanket product according to the invention.

[0025] FIG. **2** is a side partial cut-away view of an apparatus used to form a corn stover mat.

DETAILED DESCRIPTION OF THE INVENTION

[0026] While this invention may be embodied in many different forms, there are described in detail herein specific embodiments of the invention. This description is an exemplification of the principles of the invention and is not intended to limit the invention to the particular embodiments illustrated.

[0027] All published documents, including all US patent documents, mentioned anywhere in this application are hereby expressly incorporated herein by reference in their entirety. Any copending patent applications, mentioned anywhere in this application are also hereby expressly incorporated herein by reference in their entirety.

[0028] The present invention relates to a blanket/mat which can be employed for a variety of purposes such as for livestock, for revegetation, for erosion control, for potting purposes, for bare root plants, and other horticultural or agricultural purposes, and to methods of making and using the same.

[0029] The invention provides a blanket/mat product and process for making the blanket/mat product using recycled harvested corn plant waste.

[0030] As used herein, the term "corn stover materials" shall hereinafter be used to refer to the raw, unprocessed materials of the corn plant including the stalk and leaves. Desirably, the corn kernel, tassel and cob are excluded. Desirably, the stalk is cut at a point above the ground so as to avoid contaminants from the soil.

[0031] As used herein, the term "corn stover fibers" shall hereinafter be used to refer to the processed materials or defibrated corn stover material. Desirably, the corn kernel, tassel, and cob, are excluded from the process.

[0032] The process according to the invention generally includes the step of harvesting the corn stover material, treating the corn stover material to produce corn stover fibers, and mixing the stover fibers with other optional ingredients.

[0033] Suitably, the corn stover fibers are stand harvested rather than employing the conventional baled harvest method, although any method of harvesting may be employed, there are some advantages to employing the stand harvest. For example, using the conventional baled harvest method, more contaminates may be introduced into the process. Such contaminates can result in increased wear on machinery and refining parts. Contaminates include, for examples, sand, rootballs, small rocks, etc. which may be abrasive to machinery parts resulting in unnecessary wear. Thus, it may be desirable to stand harvest the corn stover material by removing the corn stalk at a point above the ground.

[0034] The standing corn crop may be harvested using any suitable method. In one embodiment, the standing corn crop is harvested using a method and apparatus as described in commonly assigned U.S. Pat. No. 5,875,622, the entire content of which is incorporated by reference herein. Using this method, a John Deere 7700 combine, modified with an integrated corn stalk chopper and rear forage blower is employed. This apparatus allows for adjustable cutting height. Suitably, the stalks are cut so as to leave about 12 inches to about 15 inches of stalk embedded in the soil in order to reduce the amount of soil and other contaminants in the collected harvest.

[0035] The chopper attachments reduce the stalks to varying lengths. Such lengths may be from about 3 inches to about 4 inches although this length may be varied.

[0036] Suitably, the harvested corn stover material has a corn grain content of less than about 2 wt-% and a cob content of less than about 25-30 wt-%. Harvests having more than about 2 wt-% corn grain or about 30 wt-% cob content may be reseparated. While such ranges are preferable, the numbers may vary.

[0037] The harvested corn stover material may have a moisture content of about 20 wt-% to about 30 wt-%.

[0038] Rapid rehydration, water absorption and retention have been found to be desirable properties of a blanket/mat according to the invention for some applications. Thus, it may be desirable to retain a certain moisture level in the corn stover material. If the harvested corn stover material is too dry, it is difficult to rehydrate.

[0039] Corn stover material has a cellular structure. If the internal moisture of the material is lost, the cells form closed bubbles resulting in a material which floats in water, but which itself does not absorb water and rehydrate.

[0040] During thermal treatment of corn stover material, the moisture in the cells of the corn stover material expands resulting in bursting of the cell structure which results in openings in the cells. The open cells exhibit improved absorption and rehydration properties, and exhibit improved moisture retention as well, as compared to a closed cell structure, which can occur if the corn stover material does not have enough internal moisture.

[0041] Thus, in preferred embodiments of the invention, the corn stover material retains a specific, desirable moisture content during harvesting and processing into a final blanket/mat product.

[0042] After harvesting, the corn stover material may be mixed with water, preservatives and inoculants in a process referred to in the industry as ensiling. In a preferred process, the moisture content of the ensiled stover material is between about 30 wt-% and about 70 wt-%. Once ensiled, the corn stover material may be covered tightly to remove any oxygen and stored in appropriate storage facilities such as cement bunkers to await further processing.

[0043] The corn stover material may be stored prior to use in the present invention. For such purposes, it has been found beneficial to preserve the amount of naturally occurring moisture in the plant cells during storage and prior to processing as discussed in some detail above. Thus, the corn stover material may be ensiled wherein additives including, but not limited to, water, inoculants, preservatives, etc. may be added to the stover material for storage.

[0044] One example of a suitable inoculant is Silamax® 50G, a lactic acid producing bacteria.

[0045] One example of a suitable preservative is dried molasses.

[0046] After ensiling, the corn stover material may be reduced to corn stover fibers, mixed with optional ingredients, and formed into a final blanket/mat product.

[0047] The process which includes the steps of forming corn stover fibers from the corn stover material, mixing with optional ingredients, and forming the mixture into a blanket/mat product, may be referred to herein as a "substantially dry process" of making a blanket/mat product.

[0048] The process employed herein, may be referred to as a "substantially dry process" for making a fibrous blanket/mat product. As used herein, the term substantially dry shall refer to a process wherein the during the processing of the corn stover material into fibers and finally into a final blanket or mat product, there is no slurry or waste byproduct that has to be discarded. This is in opposition to a process wherein a wet fiber slurry of recycled waste fiber products is processed.

[0049] During processing, suitably, the corn stover fibers suitably have a moisture content of no greater than about 25-30 wt-%, and more suitably, the moisture content is no greater than about 15 wt-% to about 25 wt-%.

[0050] After ensiling, the corn stover material may then be reduced to stover fibers. The corn stover materials may be reduced to stover fibers using any method known in the art. Suitably, the integrity of the starting stover material can be preserved during the reducing process.

[0051] Equipment including granulators and/or refiners may be employed to reduce the corn stover materials to stover fibers. Use of a refiner in series with a granulator has been found to increase the volume of stover fibers and improve efficiency. In general, a granulator may reduce the stover materials to any desired size. However, the volume of stover fiber that may be processed through a granulator is typically less than the volume of corn stover that can be processed through a refiner. Thus, for small volume products or processes, a granulator alone can efficiently be used to reduce the corn stover materials to fibers. For larger volume processes, a granulator can initially reduce the size of large corn stover materials and then the smaller corn stover materials can be reduced to stover fibers in a refiner.

[0052] In one embodiment of the invention, the corn stover materials are initially reduced in size using a granulator, and then further reduced in length using a refiner.

[0053] In one embodiment, the corn stover material is reduced to stover fibers using a thermo-mechanical defibrating process wherein the fibers are heat treated.

[0054] It is desirable to retain as much of the length of the raw corn stover fibers as possible. Preservation of this length not only provides for easier processing of the fibers into a blanket/mat product, but also provides improved properties such as higher strength, weavability, cohesion and stability to the final blanket/mat product.

[0055] In general, it has been found that the longer the stover fibers, the more stable the final product because longer fibers are more likely to intertwine with one another during processing which results in higher blanket/mat strength and cohesiveness.

[0056] However, stover fibers which are too long may entangle with one another and form aggregates which can clog machinery and increase processing time.

[0057] The length of the corn stover fibers may generally range from about 0.125 inches to about 1.0 inch in length. Reducing fiber length below about 0.125 inches results in fibers which are too short to produce a blanket/mat product having desirable physical properties, such as tensile strength and durability. Fibers having a length significantly longer than about 1.0 inch, can increase the difficulty of processing the fibers into a final blanket/mat product.

[0058] It is desirable that the majority of stover fibers have a length of about 0.75 inches to about 1.0 inch as longer fibers are easier to weave into a final blanket/mat product, and produce and stronger more cohesive blanket/mat product.

[0059] However, it can be expected in typical process, that the majority of stover fibers may have a length in the range of about 0.25 inches to about 0.50 inches.

[0060] Although uniform fiber length is desirable, it is difficult to produce fibers of a uniform length, and in a typical process, fibers having varying lengths may result. For example, some fibers may have a length in the range of about 0.25 inches to about 0.50 inches, some may have a length of greater than 0.5 inches, and some may have a length of less than 0.25 inches.

[0061] In a typical embodiment, it may be expected that about 50% to about 60% of the stover fibers have a length between about 0.25 inches and about 0.50 inches.

[0062] In one embodiment, it was found that about 50% to about 60% by weight of the fibers had a length in the range of about 0.25 inches to about 0.50 inches, about 20% to about 30% had a length in the range of about 0.125 inches to about 0.25 inches, and about 20% to about 30% had a length in the range of greater than 0.50 inches.

[0063] A preferred embodiment may include a mixture of stover fibers wherein about 75 wt-% of the fibers have a length of greater than about 0.50 inches and about 15 wt-% have length less than about 0.25 inches.

[0064] The corn stover material may then be mixed with a variety of optional ingredients. Optional ingredients which may be incorporated into the blanket/mat product may include, but are not limited to, bonding fibers, adhesive compositions, resins, thermo-plastic resins, thermo-setting resins, hot melt adhesives, waxes, wetting agents, colorants, perfumes, netting, inoculants, preservatives, fire retardants, synthetic fibers, other natural fibers, polyester and co-polymers thereof, polyamid and co-polymers thereof, polyolefin and co-polymers thereof, acetate, rayon, cotton, leather, wool, coconut, kanaffe and jute, and mixtures of any of the above. One or more of these optional ingredients may be incorporated with the corn stover fibers by blending or mixing, for example.

[0065] Optionally, bonding fibers, adhesive compositions or other bonding agents may be incorporated with the corn stover fibers to improve adhesion and therefore cohesion and strength of the final mat product. Such optional materials may be incorporated using any suitable method known in the art such as by blending, spraying, dipping, brushing, etc.

Bonding Fibers

[0066] Bonding fibers are those fibers that can be added to provide adhesion to the mat product so as to adhere the corn stover fibers together thereby providing a more cohesive, higher strength final blanket product. These fibers may be

polymeric in nature and may be thermoplastic, for example. When heated to a temperature sufficient for a particular fiber product, the product becomes sufficiently fluid and when cooled, is sufficiently adhesive to adhere the fibers together. The adhesion achieved via the bonding fibers is sufficient to permit movement of the formed but non-cured mat.

[0067] The bonding fibers may also have an adhesive coating thereon which when heated, becomes fluid and when cooled has sufficient adhesion to adhere to the corn stover fibers. Such bonding fibers are typically synthetic fibers coated with hot melt or thermoplastic adhesive coating. Any bonding fiber that has a melt temperature which is less than that of the stover may be employed herein. Examples of suitable synthetic bonding fibers include, but are not limited to, polyester fibers, polyamide fibers, polyethylene fibers, acetate fibers and rayon fibers. Natural cotton fibers or other natural fibers can also be employed herein. One commercially available bonding fiber suitable for use herein is CELLOBOND® 105 (Hoechst Celanese).

[0068] Bonding fibers may have a length of about 0.5 to about 1.5 inches, and have a denier of about 3. It is desirable that such fibers can be uniformly dispersed with the stover fibers and other components during the blending process.

Resins or Polymers

[0069] Resins or polymers may optionally be incorporated with the corn stover fibers. These resins or polymers may be thermoplastic or thermosetting in nature. Thermoplastic polymers or resins may have melting temperatures in the range of about 85° F. to about 350° F. This range is intended for illustrative purposes only, and the melting temperature may fall outside of this range for some materials. The resins, as the bonding fibers, may also be added to adhere the fibers together and to therefore increase the durability, stability and cohesion to the final blanket/mat product. They also can be added to improve moldability, particularly the thermoplastic resins or polymers. Resins useful in the present invention are preferably thermoplastic, and are also preferably recyclable. Thermoplastic resins are preferred over thermosetting resins because it is easier to reshape and recycle thermoplastic resins. Thermosetting resins tend to have less flexibility. Thermoplastic resins can be heated to their molten state during the pressing process, explained below, once solidified, improve the cohesion of the final stover product.

[0070] The addition of thermoplastic resins or polymers to the composition facilitates molding of the final product into particular shapes and sizes. However, it is noted that the stover fiber product of the invention can be obtained without use of a resin.

[0071] Examples of suitable classes of thermoplastic resins or polymers include, but are not limited to, polyamides, co-polyesters, styrene co-polymers, thermoplastic urethanes and polyurethanes, etc. Specific examples of polymers or resins useful herein include, for example thermoplastic polyurethanes commercially available from BASF; thermoplastic polyolefins commercially available from Dow Plastics; styrene block co-polymers commercially available from Dexco Polymers; and thermoplastic polyamides and copolyesters commercially available from Elf Atochem.

[0072] Thermosetting products are available from the H.B. Fuller Co. in St. Paul, Minn.

[0073] Specific examples of suitable resins or polymers are included in the table below.

TABLE 1

Resin		Type	Source	City, State
Aspun ®	6835A 6811A 6806A 6831A 6830A	TP	Dow Plastics	Freeport, TX
Vector ®	6241D 6400D 8550D 2518D	TP	Dexco Polymers	Houston, TX
Platamid ®	H005 H103 M548	TP	ELF Atochem	Philadelphia, PA
Fulatex ®	PN 3408	TS	HB Fuller	St. Paul, MN

(TP = thermoplastic; TS = thermoset)

[0074] It is desirable that the resin is easily dispersed during a mixing stage, for example, and that the resin flows upon heating, such as with a thermoplastic resin, or prior to curing, such as with a thermoplastic resin, such that the corn stover fibers obtain a sufficient coating of the resin. It is undesirable for the resin to coagulate or agglomerate into clumps during processing. Resins which have been ground into a powder prior to mixing with the stover fibers may be preferable for use herein. Resin powder is generally readily dispersed during mixing and melts evenly and quickly. Thus, if resin pellets are used, for example, preferably the pellets are ground typically to not greater than 70 mesh, prior to adding the resin to the composition.

[0075] Resin selection may vary with the end use of the stover product. For example, if a styrene block copolymer is used, then the amount of styrene in the copolymer can determine whether the stover mat product is soft or hard. Too much resin can result in a hard, brittle end product, and too little resin can result in lack of cohesiveness in the final blanket/mat product resulting in a blanket/mat product which is not stable. If resin is employed, an illustrative ratio may be about 60:40 to about 90:10 fiber to resin.

Other Additives

[0076] Other optional ingredients may also be incorporated with the corn stover fibers, for example, to facilitate processing and formation of the reconstituted stover product, and to help maintain the desired appearance and physical properties. These additives include, but are not limited to, wetting agents, colorants, fire retardant additives, as well as other fibers for improving the strength and woven appearance of the product.

[0077] Optionally, fibers other than the corn stover fibers or bonding fibers described above may be incorporated into the composition to improve the physical properties such as strength and durability as measured by slit and stitch and/or to improve the appearance of the final product such as the woven nature. The type and amount of additive fiber used varies with the desired strength and end use of the stover product.

[0078] Suitably, the optional additive fibers are long, for example in the range of about 0.75 to about 1.50 inches, are high strength, having a denier of about 15. Suitable additive

fibers also easily intertwine with the stover fibers and/or bonding fibers so as to provide strength to the final product. Examples of suitable fibers include, but are not limited to, polyester, polyamide, polyethylene, acetate, rayon, cotton and other natural or synthetic fibers. Additive fibers are especially useful when the corn stover fibers and/or bonding fibers, for example, are relatively short.

[0079] The optional fibers may be the same as or different than the bonding fibers, but may lack the adhesive coating, in the case of some bonding fibers.

[0080] One specific example suitable optional additive fiber product is the Trevira® polyester fiber **103** commercially available from Hoechst Celanese of Salsbury, N.C., of 15 denier.

[0081] Another suitable commercially available additive fiber is Fybrel®-901 available from MiniFibers in Johnson City, Tenn. The addition of about 10 wt-% of the polyethylene product, Fybrel®-901 based on the total composition weight, for example, may provide a strong product that has increased slit and stitch values when compared with the same product having no additive fiber.

[0082] A wetting agent can also be added during the blending process. A wetting agent can facilitate the complete dispersion of the resin throughout the mixture. Particular wetting agents are used and/or sold with particular types of resins. Preferably, the wetting agents are recyclable.

[0083] Fragrance agents and coloring agents, such as dyes, may also be added during a blending process in order to impart desired odor and color to the final product. Dyes and coloring agents are known to those of skill in the art. Any suitable dyes or coloring agents known in the art may be employed herein.

[0084] Ingredients which impart water repellency to the final blanket/mat product, such as waxes, may also be incorporated into the blanket/mat product herein, such as during the blending process. Such ingredients may also be sprayed or brushed onto the product, or the product may be dipped in such ingredients.

[0085] It is understood that any components added to the composition should not interfere with the structural or physical integrity of the stover fibers. Furthermore, any components added to the composition desirably do not interfere with the bonding, of the polymers or resins, or the bonding fibers. Suitably, each component added to the composition is recyclable and/or biodegradable.

[0086] The components may be added to the stover fibers using any suitable method known in the art. One method is to blend the ingredients together in a mixing device, for example, such as a Waring® blender. It is desirable that the mixture be relatively uniform throughout.

[0087] Limited amounts of water may be added during the blending process in order to maintain the moisture level of the stover fibers at least at about 10 wt-% to about 25 wt-% of the stover fibers. It is most desirable to maintain a moisture content of about 15 wt-% for optimum processing and end results. However, it is desirable to have a minimum amount of freestanding water in the mixing vessel; however the amount of water should not be sufficient to permit a slurry to form. It is less economical to form a slurry because of water removal and/or waste slurry disposal.

[0088] If the amount of moisture is greater, the time of blending may be increased to remove more water during this step. Suitable temperatures for use during the blending step may depend on the melting temperature of the ingredients added. In order to ensure evaporation of excess water, however, blending temperatures must be at least about 100° F.

[0089] It is desirable that the stover fibers form the largest part of the total composition by weight. Such amounts will vary depending on the end use of the stover blanket/mat product formed herein. A minimum amount of the optional additive fibers including the bonding fibers or synthetic fibers described above may be used in order to ensure enough cohesion in the final blanket/mat product.

[0090] Suitably the amount of stover fiber is about 50 wt-% to about 80 wt-% of the final blanket/mat product. In one embodiment, between about 55 wt-% to about 65 wt-% of the stover fibers are employed.

[0091] Bonding fibers are suitably present in amounts of about 0 wt-% to about 20 wt-%, more suitably about 0 wt-% to about 10 wt-% of the final blanket/mat product. In some embodiments, it may be desirable to employ more than 20 wt-% of the bonding fibers. In one embodiment, up to about 5 wt-% of polyester fibers having an adhesive coating thereon are employed.

[0092] After blending, the composition may be formed into a blanket/mat product immediately, or the composition may be stored for a time prior to the forming process.

[0093] The composition may then be transferred to a former, for forming into a blanket or mat. If the mixture is transferred directly from the mixing vessel to the former, it may be done via feeding or pre-feeding equipment, suitably metered equipment. Such feeding or pre-feeding equipment is available from Rando Machine Corp. in Macedon, N.Y. under the tradename of Rando Prefeeder® and Rando Feeder®.

[0094] Any suitable equipment for forming the blanket or mat products described herein may be employed. One example is a mat or blanket former which includes an air laid forming process. An example of a commercially available former of this type is one produced by Rando Machine Corp. in Macedon, N.Y.

[0095] In using the air-laid former, typically the blended mixture is poured onto screens which are subjected to air blown against the top of the screen. During the air-laid process, typically heavier elements of the stover fiber mixture settle to the bottom of the formed product, whereas lighter materials are positioned proximate to the top.

[0096] Optionally, a netting may also be incorporated into the blanket of the invention for further reinforcement, for example. The netting may be formed from biodegradable materials such as from biodegradable polymeric materials such as polyhydroxyvalerate-hydroxybutyrate, polycaprolactone, polylactic acid, and mixtures thereof. The blanket/mat can also be formed onto the netting.

[0097] The resultant blended product may then be employed to form a final blanket/mat product.

[0098] The process employed herein, while some moisture is suitably retained in the corn stover fibers, may be referred

to as a "substantially dry process" for making a fibrous blanket product or mat. As used herein, the term substantially dry shall refer to a process wherein during formation of the blanket/mat product, the corn stover fibers have a moisture content which does not exceed about 25-30 wt-% and more suitably, the corn stover fibers have a moisture content of no more than about 15 wt-%. A wet fiber slurry is not typically formed using the present invention, as opposed to other processes wherein wet fiber slurries of recycled waster fiber products are processed.

[0099] If the fibers have a moisture content of significantly less than about 10 wt-%, it has been found that the fibers become brittle and inflexible, and generate significant amounts of dust. The existence of dust and reduced moisture content for the fibers may increase the risk of the fibers charring or spontaneously combusting. Furthermore, dryer fibers result in blanket/mat product which has less strength and less cohesion, and holes may develop in the final blanket/mat product.

[0100] Stover fibers having a moisture content of significantly greater than about 25%, result in diminished processing efficient and increased processing costs.

[0101] Turning now to the figures, FIG. **1** illustrates generally at **10**, by way of a flow chart, one embodiment of a process of making a corn stover blanket/mat product according to the invention.

[0102] Corn stover material can be initially reduced into fibers using any suitable means known in the art. In the embodiment shown in FIG. **1**, corn stover materials are placed in a granulator **12** which reduces the corn stover material into smaller parts for further processing by cutting. The raw corn stover materials may be transported in the form of enlarged bails for processing in the granulator **12**. Upon exit from the granulator, the initially reduced corn stover material may be transported to a refiner **14** for further reduction. The initially reduced material may be transported from the granulator **12** to the refiner **14** using any suitable method known in the art. In one embodiment, the stover fiber materials are transferred by a conveyor system (not shown) from granulator **12** to refiner **14**.

[0103] Suitably, in addition to the conveyor system, if necessary, any suitable method of imparting moisture to the initially reduced material is also employed. Thus, prior to entry of the initially processed stover materials into the refiner **14**, the corn stover materials may be preheated and exposed to dry steam such that the moisture content of the corn stover material is approximately 50 wt-% to 60 wt-%. In one embodiment, the corn stover material was heated to a temperature of about 250° F.

[0104] Upon exit from granulator **12**, the corn stover material/fibers may contain less than 15% moisture. Thus, if the conveyor system has the capability of imparting moisture to the stover materials as they are being transported from granulator **12** to refiner **14**, then, if needed, moisture can be added to the stover fiber materials at this stage. Enough water should be added such that the moisture of the stover fiber materials entering the refiner **14** is at least 10% by weight.

[0105] The moisture content of a known sample stover material may be measured using a moisture meter, such as that commercially available from Denver Instruments as Model No. 1R-200.

[0106] Throughout the reduction process, it is desirable to retain at least about 10 wt-% to about 25 wt-% moisture in the fiber material. The increased moisture content and heat assists to breaks down the stover fibers and further retards the chance of charring or burning of the fibers in the refiner **14**. Furthermore, the moisture facilitates reduction of the fibers without creating significant amounts of stover dust which can spontaneously combust. However, it is not desirable to have a sufficient volume of water to create a slurry. Creation of a slurry decreases the efficiency of the process because excess water and slurry waste must then be removed from the process.

[0107] Another method of transporting the material from the granulator to the refiner is by metering through an auger and feed system to establish a uniform weight of product prior to entering refiner **14**.

[0108] It is desirably to maintain the temperature in the refiner between about 200° F. to about 300° F., and more preferably between about 220° F. and about 250° F. Temperatures of about 350° F. or more, can result in a significant amount of the stover material charring or burning in the refiner **14**.

[0109] Suitable refiners are those having metal plates wherein stover material parts are converted to fibers by destruction of the matrix around the fibers while maintaining fiber integrity. One example of a suitable commercially available refiner is available Andritz, Sprout & Bauer of Springfield, Ohio. In one embodiment, refiner **14** has two has two opposed metal plates that are applied to the stover material and rotated so as to tear the stover material apart, thereby releasing the fibers. Any suitable metal refining plates may be employed herein. Various size metal plates can be used depending upon the desired fiber size.

[0110] One example of commercially available refiner plates having suitable configuration are those available from Durametal Corporation (Tualaton, Oreg.) formed of C-20 alloy and having a #336 Circle with a 005/in. TRO taper (#30-36505-217).

[0111] Suitably, refiner **14** is operated at a temperature and mixing speed that is sufficiently high to permit the stover materials to be efficiently pulled apart, but the temperature and speed should not be so high as to cause the stover materials to burn, denature, or generate significant amounts of dust. Some water may be added to the stover parts during refining in order to maintain, or to insure, the moisture in the stover is maintained between about 10 wt-% and about 25 wt-%. The temperature and mixing speed in refiner **14** may be adjusted to prevent dehydration of the stover. If too much water is added to the stover during the reduction process, however, stover dust can agglomerate or aggregate and clog the equipment, which may decrease the tendency for creating a uniform product.

[0112] The refiner mixing speed varies with the volume of materials to be processed, the size and type of equipment used and the heat generated during mixing. Preferably, the mix speed is low enough that the intensity and strength of the stover material is preserved, and preferably, the mix speed is high enough so that processing time is minimized.

[0113] Upon exiting the refiner, if the moisture content of the stover fibers is greater than about 15 wt-% to about 25 wt-%, it may be desirable to expose the stover fibers to a

dryer immediately upon exiting the refiner in order to reduce the moisture to a level of about 15 wt-% or so. The dried stover fibers may then be bailed, bagged, and/or compressed for storage for further processing, or they may be immediately processed further. If drying is desired, the stover fibers may be transferred to any suitable equipment such as a heating unit and/or cyclone, to adjust the moisture level to between about 10 wt-% to about 25 wt-%. The heating unit should not be so warm that it burns or dehydrates the stover fiber. Any heating unit and/or cyclone known in the art may be used.

[0114] Alternatively, if the moisture level is below about 10% by weight, water may be added to the fibers prior further processing of the fibers. However, there should not be so much water added that the moisture of the stover is greater than about 25% by weight.

[0115] The stover fibers may then be transferred to a mixer, blender or other such suitable mixing vessel **16** for blending with other optional ingredients as desired such as bonding fibers, resins and optionally other additives, as discussed above. Suitable mixing vessels include any standard high shear mixing vessel. One example of a suitable mixing vessel which can be employed herein is a Waring® blender. The mixing action provided by a Waring® blender does not destroy the integrity of the stover fibers yet provides enough mixing of the various ingredients to provide a homogenous mixture. Speeds of about 300 rpm's have been found to be suitable for use herein. Mixture time can vary depending on the type of mixing vessel employed. When using a Waring® blender, adequate mixing can be obtained in as little as about 1 minute to about 3 minutes.

[0116] The resultant mixture is a substantially dry mixture in that a slurry is not formed. Some water may be added during the blending step in order to maintain a moisture content in the stover fibers of about 10 wt-% to about 25 wt-%, but not so much that there is standing water in the blender and not so much as to form a slurry.

[0117] If too much water is present, the time of the blending step may be increased so as to evaporate water. A temperature of at least about 100° F. may be required to efficiently remove water.

[0118] After blending, the composition may be stored for later use, or may be employed immediately to form a blanket/mat product. As shown in FIG. **1**, the composition is transported from mixing vessel **16** to a former **17**. Former **17** may be optionally connected to a hopper (not shown) into which the composition is placed prior to entry into former **17**. The blended composition may be transferred to the former using any suitable feeding or pre-feeding equipment known in the art. Former **17** is shown in detail in FIG. **2**. In this embodiment, former **17** forms a blanket/mat using an air-laid forming process. One such type of air laid former is available Rando Machine Corp., Macedon, N.Y.

[0119] Use of feeding and/or pre-feeding equipment which is metered may insure that the constituents are evenly dispersed throughout the mixture prior to being fed into former **17**. Such types of equipment are available as the Rando Prefeeder and Rando-Feeder® from Rando Machine Corp. of Macedon, N.Y.

[0120] In general, the blended materials having a desired moisture content (as discussed above), are suitably placed in the storage container **30** which can then be emptied into the hopper **30**, when desired, to start the forming process. Alternatively, the blended materials may be placed directly into the hopper **32** at the discretion of an operator. In general, the mixed and/or blended materials can be metered from the storage bin **30** or hopper **32** into the former **17** so that the feeding equipment in former **17** may maintain a uniform level of raw material for formation into a dry blanket.

[0121] The materials are generally transported from the hopper **32** via a conveyor **34**. A meter **36** at the top of the conveyor **34** regulates a desired amount of fibers to be processed at a forming head **38** where the materials then start to catch and intertwine together forming a web-like blanket or mat.

[0122] Alternatively, the amount or volume of fibers for formation into a dry web-like blanket/mat may be regulated by doffing of the fibers by a regulated air flow adjacent to an air bridge **40**. The flow rate of air adjacent to the air bridge **40** determines the quantity of fibers conveyed and is governed by both the speed of the continuous feed blanket formation on the condenser screen **42** and as regulated by the air volume control **44**.

[0123] Generally the air pressure above the feed mat condenser is below atmospheric pressure, which in turn causes air to flow through the condenser screen and into a suction duct.

[0124] As the feed mat takes shape, the air flow is reduced due to the resistance of the feed mat and the condenser screen proximate to the air bridge **40**. Proportionately less doffing occurs until an equilibrium condition is achieved. At this time, sufficient tufts of stover fibers are doffed to form a continuous uniform dry feed mat.

[0125] The feed mat condenser drive is preferably synchronized with the feed roll drive to maximize efficiency in the formation of the dry feed mat. A dry feed mat is then preferably doffed onto the feed plate **46** which then passes under the feed roll **48**. The feed roll **48** feeds the dry feed mat onto the concaved surface of the nose bar **50** which exerts a hold action as the dry feed mat is fed over the top of the nose bar **50** and onto the path of the lickerin **52**. Loose fibers may then be separated from the dry feed mat by the lickerin **52** and introduced into the air stream generated by a fan **54**. The velocity of air from the fan **54** is controlled by a saber **56**. The saber **56** may be rotated to either narrow or widen the opening, between the saber **56** and the lickerin **52** to increase or decrease the air velocity in a manner similar to a venturi **58**. Airborne fiber may then be carried into a duct area for transportation to the condenser to be used in the formation of the dry feed mat as shown in condenser area **60**. Proximate to the condenser area **60**, fiber is preferably uniformly deposited on the revolving condenser screen and is aerodynamically formed into a continuous random fiber web structure as air passes through the fiber into the closed duct system. The web then flows from the condenser screen onto the take-away conveyor **62** for further processing.

[0126] As the fiber passes the air bridge **40**, the fiber is transported by the forming head conveyor **39** to the forming head **38**. As the web passes into the lickerin **52**, the web is destroyed and is reconstituted via a vacuum-forming table. Reconstitution is accomplished through the use of a polyester screen which has a vacuum section below the screen

for drawing tile fibers onto the screen through the use of air pressure. The vacuum effect and air pressure properly arrange the fibers to create a non-woven air-laid fiber blanket/mat. Air pressure is exposed to the fibers from above and to the polyester screen and a vacuum exists below to form the non-woven air-laid felt blanket/mat by an essentially dry process.

[0127] A conveyor may then be employed to transport the non-woven air-laid felt blanket/mat into a curing oven **18** (FIG. **1**) having a vacuum below the conveyor which is a perforated screen. The non-woven air-laid blanket/mat can be exposed to hot air from the conveyor which can be suctioned through the mat or blanket through the use of a vacuum for increased efficiency. The hot air is preferably heated to a temperature of about 300° F. to about 350° F. which, when drawn by the vacuum, causes the blanket/mat to dry very quickly. As the blanket or mat is dried, the temperature for the blanket/mat begins to rise which in turn can heat the bonding fibers to a temperature at which the adhesive coating flows sufficiently or melts, causing the binding fibers to become sticky and to adhere to any adjacent stover fibers. The vacuum oven typically suitably extends over a distance of about 12 to about 18 feet for satisfactory efficiency. As the blanket/mat exits the vacuum oven, squeeze and/or lift rollers compress the heated blanket/mat.

[0128] The blanket/mat may then be passed to a cooling section which consists of the take-away conveyor **62** which also includes a vacuum positioned below the take-away conveyor **62** to draw ambient air through the product to cool the blanket/mat to ambient or room temperature. The product may then be cut to a desired size.

[0129] The formed blanket/mat as it emerges from the air-laid former is then passed through a drying oven **18** wherein if an adhesively coated bonding fiber is employed, the adhesive coating begins to flow or ultimately melt, to initiate formation of a cohesive blanket/mat. In one embodiment, the blanket/mat may be passed through the oven **18** at a rate of about 10 to about 20 feet/minute, suitably about 15 feet/minute and the oven temperature employed may be held between about 300° F. and about 350° F. Preferably, the oven temperature is high enough to melt the coating on the bonding fibers and/or to begin melting any resin which may have been added to the stover fiber composition. Suitably, the temperature in the oven is kept below that at which the resin melts completely. During the time in which the blanket is in the oven **18**, drying occurs and any excess moisture in the blanket/mat product can be evaporated. The dried, formed, reconstituted stover product exits the oven **18** in sheet form and may be rolled up and packaged for later sale.

[0130] As the blanket/mat exits the vacuum oven, squeeze and/or lift rollers compress the heated mat.

[0131] The blanket/mat may alternatively be formed over a netting, and suitably, a recyclable or biodegradable netting. Biodegradable netting may be formed from polylactic acid, polycaprolactone, polyhydroxyvalerate-hydroxybutyrate, for example, and mixtures thereof.

[0132] The resultant blanket/mat may have a non-woven appearance.

[0133] The blanket/mat may be employed for revegetation, erosion control, for livestock blankets, and in greenhouses and nurseries for potting plants and for bare root trees, shrubs and plants, for example.

[0134] The above disclosure is intended to be illustrative and not exhaustive.

[0135] This description will suggest many variations and alternatives to one of ordinary skill in this art. All these alternatives and variations are intended to be included within the scope of the attached claims. Those familiar with the art may recognize other equivalents to the specific embodiments described herein which equivalents are also intended to be encompassed by the claims attached hereto.

[0136] While this invention may be embodied in many different forms, there are described in detail herein specific preferred embodiments of the invention. This description is an exemplification of the principles of the invention and is not intended to limit the invention to the particular embodiments illustrated.

[0137] For the purposes of this disclosure, like reference numerals in the figures shall refer to like features unless otherwise indicated.

[0138] The above disclosure is intended to be illustrative and not exhaustive. This description will suggest many variations and alternatives to one of ordinary skill in this art. All these alternatives and variations are intended to be included within the scope of the claims where the term "comprising" means "including, but not limited to". Those familiar with the art may recognize other equivalents to the specific embodiments described herein which equivalents are also intended to be encompassed by the claims.

[0139] Further, the particular features presented in the dependent claims can be combined with each other in other manners within the scope of the invention such that the invention should be recognized as also specifically directed to other embodiments having any other possible combination of the features of the dependent claims. For instance, for purposes of claim publication, any dependent claim which follows should be taken as alternatively written in a multiple dependent form from all prior claims which possess all antecedents referenced in such dependent claim if such multiple dependent format is an accepted format within the jurisdiction (e.g. each claim depending directly from claim **1** should be alternatively taken as depending from all previous claims). In jurisdictions where multiple dependent claim formats are restricted, the following dependent claims should each be also taken as alternatively written in each singly dependent claim format which creates a dependency from a prior antecedent-possessing claim other than the specific claim listed in such dependent claim below (e.g. claim **3** may be taken as alternatively dependent from claim **2**; claim **4** may be taken as alternatively dependent on claim **2**, or on claim **3**; claim **6** may be taken as alternatively dependent from claim **5**; etc.).

[0140] In addition to being directed to the embodiments described above and claimed below, the present invention is further directed to embodiments having different combinations of the features described above and claimed below. As such, the invention is also directed to other embodiments having any other possible combination of the dependent features claimed below.

[0141] The present invention may be embodied in other specific forms without departing from the spirit or essential

attributes thereof, and it is, therefore, desired that the present embodiment be considered in all respects as illustrative and not restrictive, reference being made to the appended claims rather than to the foregoing description to indicate the scope of the invention.

[0142] This completes the description of the preferred and alternative embodiments of the invention. Those skilled in the art may recognize other equivalents to the specific embodiment described herein which equivalents are intended to be encompassed by the claims attached hereto.

1-13. (canceled)

14. A method of making a blanket, the method comprising the steps of:

a) harvesting a corn crop to obtain corn stover material; and

b) defibrating said corn stover material to form stover fibers.

15. The method of claim 14 further comprising the step of mixing with said corn stover fibers at least one member selected from the group consisting of bonding fibers, adhesives, thermoplastic resins, thermosetting resins, waxes, natural fibers, synthetic fibers, wetting agents, colorants, perfumes, netting, fire retardants, and mixtures thereof.

16. The method of claim 14 further comprising the step of positioning said blanket for erosion control, revegetation, livestock or plant retention.

17. The method of claim 16 further comprising the step of adding a scrim or netting to said blanket.

18. The method of claim 16 the blanket comprising a bonding fiber comprising a coating of a thermoplastic adhesive, the method further comprising the step of heating the blanket to a temperature sufficient to cause the hot melt adhesive to flow.

19. The method of claim 14 the corn stover material comprising substantially corn stalk and corn leaves.

20. The method of claim 14 wherein said method is a dry method wherein said corn stover material has a moisture content of about 10% to about 30% by weight.

21. The method of claim 14 further comprising the step of ensiling wherein said ensiling comprises adding water, inoculants, preservatives and mixtures thereof to said corn stover material prior to defibrating.

22. The method of claim 14 wherein said defibrating is done thermo-mechanically.

23. (canceled)

24. A method for controlling erosion from soil with a blanket used as a temporary ground cover, the method comprising:

providing a degradable erosion control blanket in a roll form the degradable erosion control blanket comprising about 25 to 99 wt-% corn stover fibers and about 1 to 5 wt-% polymeric binder fibers, and any remainder being selected from the group consisting of other natural fibers and synthetic fibers and mixtures thereof;

unrolling said blanket on said soil; and

securing said blanket into place.

* * * * *