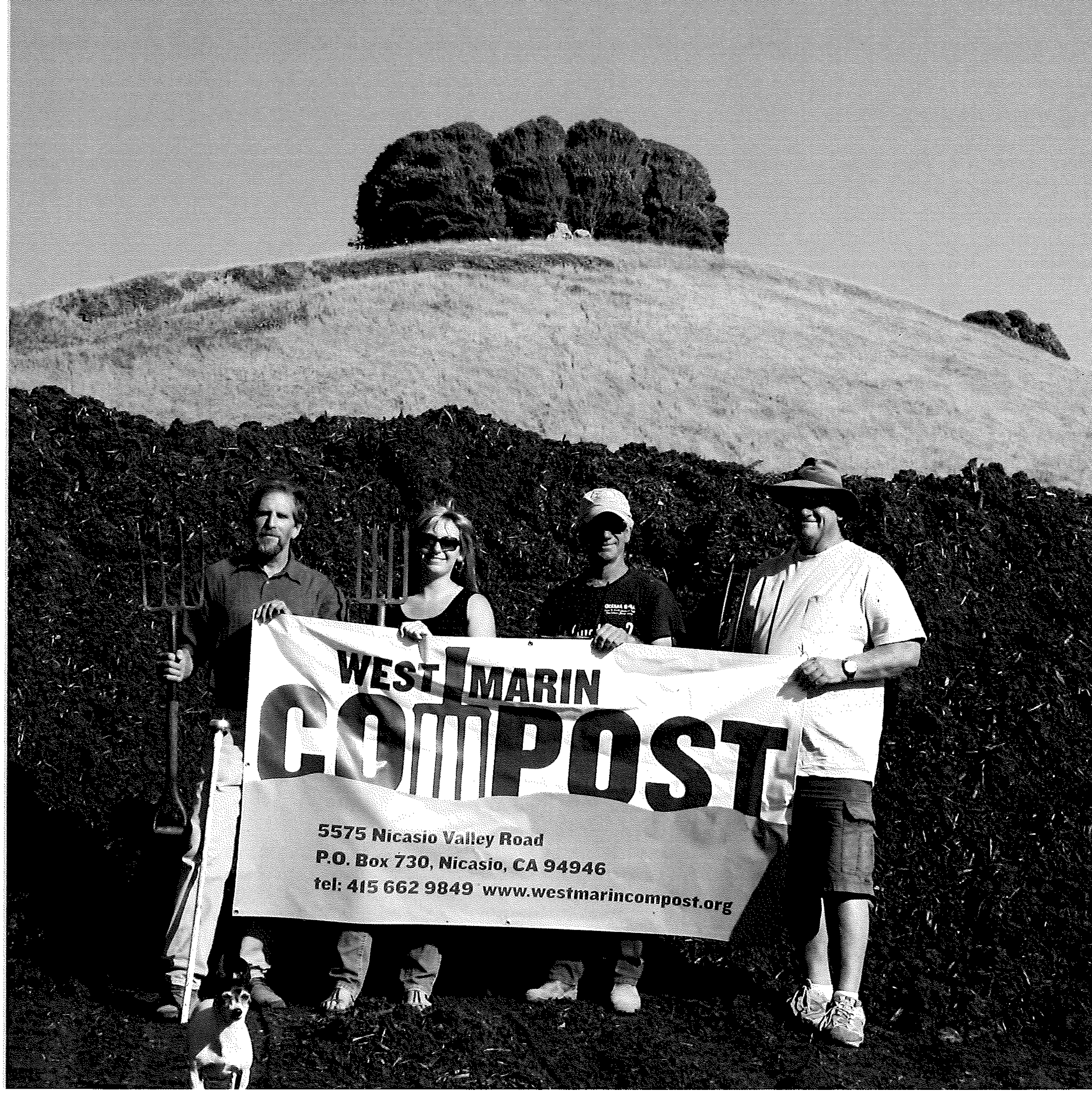
-FINAL-

Co-composting of Agricultural Green Wastes in West Marin County for Dairy Bedding, Water Quality Protection and Soil Quality Enhancement

Marin Resource Conservation District
August 2006 – November 2012
Grant Number 68-3A75-6-141
December 31, 2012



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I. Executive Summary

The West Marin Compost Project (WMCP) was designed to address West Marin County's need for a local, environmentally sound, strategy for managing its organic residuals, while restoring and enhancing the fertility of its rangeland and agricultural soils. At the same time, the project models a solution to the growing climate crisis. WMCP demonstrates the viability of composting as a tool for enhancing the environmental and economic sustainability of natural resource management and utilization activities in West Marin and beyond. The establishment of a centrally located compost facility solves a multitude of resource issues in the County including:

- Nonpoint source pollution issues at local dairy and equestrian facilities
- Lack of economically feasible dairy bedding options for farmers
- Increased greenhouse gas emissions associated with dairy, green waste and compost trucking
- Lack of available compost for soil amendment of rangeland and local residential garden and landscapes

WMCP addressed these issues by establishing a community green waste drop off facility and compost operation. Dairy and equestrian manure and bedding is co.mbined with community green waste to produce organically certified compost made available to local dairy farmers, livestock operations, landscaping companies and residents.

The intended goals and objectives of the project were fulfilled although many difficulties arose in the unforeseen drop off site planning and compost permitting process which delayed completion of the project by three years. Additionally, new greenhouse gas emission laws for compost equipment also slowed the project. Budgets associated with these hurdles required additional fundraising which were eventually provided by the County of Marin and Redwood Empire Disposal, while USDA Conservation Innovation Grant (CIG) budgets associated with the construction of the compost facility and drop off site remained relatively consistent.

Despite these delays, WMCP prevailed with the help of many local, state and federal partners. The project's priority to improve on-farm efficiency by reducing hauling and equipment maintenance costs associated with the importation and use of sand as a bedding material, enhancing forage production via improved soil quality and water holding capacity and reducing costs associated with the hauling and spreading of wet manures was accomplished. The project produced the following quantifiable physical results:

- The establishment of a centrally located community green waste drop.off and composting facility serving West Marin's agricultural, wildland and rural residential components.

- A local manure and bedding disposal site for :1 dairy and 5 equestrian facilities.
- 8,000 yrds^3 of compost produced in year I for bedding and soil quality enhancement.
- 1260 tons C02/4624 tons C02e sequestered in Marin's agricultural soils as indicated by research conducted by UC Berkeley.
- ' Educational and outreach including West Marin Compost website, KWMR news brief, University of California Cooperative Extension Service (UCCE) Grown in Marin website, West Marin Resource Guide, Marin Resource Conservation District (Marin RCD) website, Compost at the Commons Educational Workshop.

The benefits of the project are far reaching and timely. As farmers are faced with inevitable climate change conditions the application of compost offers a potential mitigating solution to variable soils characteristics associated with such change. Compost soil amendments will neutralize extreme climatic conditions by increasing soil infiltration, water holding capacity and soil structure. In addition, the simple practice of compost application will mitigate greenhouse gas emissions through carbon sequestration as proven by our partnership with UC Berkeley. This research has been useful in informing the state's new mandate associated with AB1532, California Global Warming Solutions Act to establish cap and trade options.

The establishment of a central compost facility, combined with innovative carbon sequestration research, offers farmers in Marin County and beyond with a viable, economic option toward agricultural sustainability. Local farmers, equestrian facilities and residents are now able to enjoy the benefits of the WMCP and more importantly, the future may find cap and trade or mitigation credits within the grasp of farmers primed to be a part of a climate solution.

II, *Acknowledgements*

The West Marin Compost Project would not be possible if not for the very dedicated and passionate individuals, agencies and organizations whose sheer determination and patience made this project possible:

Funders

County of Marin
Lafranchi Family & Dairy
Lunny Grading and Paving/West Marin Compost
Rathmann Family Foundation
Redwood Empire Disposal
USDA Natural Resources Conservation Service Conservation Innovation Grant

Primary Partners

County of Marin
Marin Municipal Water District
Lafranchi Family & Dairy
Lunny Grading and Paving/West Marin Compost
Marin Resource Conservation District
West Marin Compost Coalition

Planning, Permitting and Construction

Bay Area Air Quality Management District
Lisa Bush, Range Management Agricultural Consulting
Stacy Carlsen, Marin Agricultural Commissioner
Jeffrey Creque, Ph.D., West Marin Compost Coalition
Gregorio Cruz & Sheila Leonard, USDA Natural Resources Conservation Service - Washington
Charlette Epifanio & Jennifer Gabor, USDA Natural Resources Conservation Service - Petaluma
Michael Frost, Marin County Public Works
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Jack Govi, Marin County Counsel
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Marin RCD Board of Directors
Nicasio Landowners Association
Jeff Rawles, Waste Management Consulting
Mark Riesenfield, MRA Consulting
Ellen Rilla & David Lewis, University of California Cooperative Extension
John Wick & Peggy Rathmann

The West Marin Compost Project (WMCP) addresses West Marin County's need for a local, environmentally sound strategy for managing its organic residuals, while restoring and enhancing the fertility of its rangeland and agricultural soils. The project also models a solution to the growing climate crisis. WMCP demonstrates the viability of composting as a tool for enhancing the environmental and economic sustainability of natural resource management and utilization activities in West Marin and beyond.

WMCP was designed to provide an innovative and comprehensive solution to multiple, significant natural resource concerns in rural West Marin County in at least four ways: 1) by producing approximately 20,000 cubic yards of compost and reducing the need for imported fertilizers, feed, and bedding material for traditional livestock producers; 2) by providing organic compost for the organic ranching and farming community of West Marin; 3) by assisting producers to meet TMDL requirements through enhanced soil nutrient and water holding capacity and, 4) through controlled processing of 36,000 cubic yards annually of nutrient rich and pathogen-bearing organic materials, including approximately 12,000 cubic yards of dairy manure and equal amounts of both equestrian and green wastes, to an environmentally beneficial material.

The omposting process is an involved but effective process. Compost biochemical processes result in the destruction of pathogenic organisms and the transformation of nutrients in manure into more stable forms that are less mobile and thus less available for contamination of surface water. The compost environment is extremely complex, but the aerobic composting process consists of 3 basic phases: ambient temperature, high temperature and maturation. The process begins with materials assembled in proper proportions, with carbon/nitrogen ratio being paramount, along with a pile moisture of approximately 60%. Microbial activity in the pile results in temperatures rising from ambient up to 175 degrees F. During this high temperature phase, (over 131 degrees F) pathogenic organisms and weed seeds are killed. Eventually, readily available microbial food sources are consumed and biological activity, along with temperature, decline. The compost then enters the maturation phase, where it is allowed to sit for a period of 30 to 90 days prior to use.

The controlled composting environment transforms relatively ephemeral plant carbon into a more stable form (compost), which means less CO_2 going back to the atmosphere than if that vegetation was left to decompose on the soil surface. Transferring stabilized carbon and associated nutrients to the soil as compost provides a source of slow release energy and nutrients for the soil ecosystem and growing vegetation, while helping to protect both soil and water quality.

WMCP was initiated by the West Marin Compost Coalition in 2006 and was composed in five different components: the processing of 1) green waste, 2) equestrian bedding material, 3) dairy manure solids, 4) marketing and outreach to the organic and non-organic farming community, dairy producers and the general public; and 5) the use of the product as an educational resource for the agricultural community, county administrators and the general public.

WMCP was designed as a public-private partnership between Lunny Grading and Paving, . Lafranchi Dairy and Marin County with technical assistance provided by the University of California Cooperative Extension Service (UCCE), Marin Organic, Marin Agricultural Commissioner and West Marin Compost Coalition. Financial assistance was provided by the USDA-Natural Resources Conservation Service Conservation Innovation Grant (CIG), County of Marin, Redwood Empire Disposal (RED), Lunny Grading and Paving and administration completed by the Marin Resource Conservation District (Marin RCD). Project partners are accomplished local county, state governments or institutions that have worked in partnership for many decades in addressing education, outreach, planning, technical and financial needs for agricultural producers in Marin County.

The compost operation is established at two centrally located sites: 1) The Lafranchi Dairy, for the compost facility and 2) the co-owned Marin County Department of Public Works and Marin Municipal Water District (MMWD) that serves as the drop off and grinding site (See Appendix A: Site Maps). To minimize noise and traffic impacts on the partnering dairy the collection and grinding of the green waste takes place at this site.

WMCP was pursued because it offers outstanding benefits. Co-composting dairy waste with low bulk-density equestrian and green wastes increases the pathogen reduction efficacy of the composting process and produces a bedding material with absorbency characteristics superior to those of dairy waste separator solids alone. Replacing sand with free-stall mattresses dressed with a few inches of compost as a dairy bedding material adds the benefit of reducing hauling costs associated with importing bedding materials from outside Marin County, reduces wear and tear on manure pumping equipment, and allows both recycling of bedding materials and soil improvement via use of compost fines as a soil amendment.

NRCS-CIG funding for the project primarily supported construction costs. The long-term economic viability of the project will be dependent upon tipping fees associated with the green waste drop-off site operation and the sale of compost. The project has proven itself to be economically self-sustaining in its first year of production.

Background:

Tomales Bay supports a two million dollar a year shellfish industry, endangered salmon and steelhead runs and is declared an impaired water body by the San Francisco Bay Regional Water Quality Control Board (RWQCB). Livestock-based agriculture, including dairy, beef and equestrian operations, have been identified as contributing sediments, nutrients and fecal-borne pathogens to Tomales Bay by raw liquid manure application and the stock piling of manures adjacent to environmentally sensitive streams. These soils and nutrients represent a significant loss of productive potential from Marin County farmlands. Hundreds of tons of nutrients are purposefully imported into the region each year in the form of inorganic and organic fertilizers and livestock feeds. This contributes to theconcentration of nutrients in West Marin waterways and Tomales Bay. WMCP was designed to help agricultural operations meet Total Maximum Daily Load (TMDL) water quality standards for tributaries to Tomales Bay.

The Marin RCD and partner agencies and farmers have put forth considerable effort in addressing the Tomales Bay Pathogen TMDL in the past five years by implementing ~4 million worth of projects resulting in the implementation of over 130 conservation practices on Matin County rangelands. It is unknown whether this effort has resulted in a net water quality improvement within the watershed. However the desired water quality targets remain unmet, therefore additional watershed work is necessary. This project would also address nonpoint source pollution reduction at equestrian facilities where implementation programs had not been previously pursued.

For more than 100 years, West Marin dairies utilized beach sand as preferred bedding material. In 2006 this naturally low-pathogen material was no longer available to dairy farmers. Therefore farmers anxiously sought a viable alternative that didn’t involve long distance trucking of materials. The proposed compost project was designed to compost dairy manure with stable bedding from several Tomales Bay watershed equestrian facilities and green waste from landscaping companies and residents. A finished local compost product would then be used to meet nutrient-balancing and/or bedding needs on a partnering dairy. Surplus would then be sold for dairy bedding as well as other agricultural, landscaping, restoration, erosion prevention or erosion control purposes throughout West Marin. Overall WMCP would provide dairy bedding, reduce trucking costs for the dairy farmer and landscapers; while reducing greenhouse gasses (GHG) associated with bedding and landscaping trucking.

V. Review of Project Methods:

In 2006 the WMCP was proposed by the West Marin Compost Coalition as a construction project and therefore planning budgets associated with project development were not anticipated. The Marin RCD Board of Directors unanimously adopted the project given the outstanding benefits it was to offer agricultural and watershed health. The unanticipated planning requirements resulted in scheduling delays. Two extensions were requested and granted during the life of the project which resulted in the successful completion of the facility. The following timeline highlights major events that occurred during the project:

2007 USDA CIG contract is initiated. Drop off site at Lunny Quarry is investigated and turned down by Nicasio Landowners Association through public review process.

2008 CIG contract is amended to eliminate.drop off site requirement due to budgetary concerns since preferred site is turned down. California Environmental Quality Act (CEQA) is pursued for compost site at Lafranchi Dairy. Lunny/Lafranchi agreement is initiated.

2009 Alternate drop off site is pursued at county/water district owned yard. Zoning restrictions are investigated. Lunny/Lafranchi agreement is finalized. Contract extension is requested from USDA.

2010 $400k funds are provided via a franchise agreement between Marin County and RED; funds provide for additional equipment cost due to passage of AB 32 California Global Warming Solutions Act. MOU is completed between Marin RCD, RED and Lunny (compost project contractor) to secure the funding agreement.

2011 Marin RCD secures the MMWD and Marin County parcels. Lot lines are surveyed, delineated before a license agreement is finalized between MMWD, Marin RCD and County of Matin Board of Supervisors.

Marin RCD received approvals from the California Integrated Waste Management Board (CalRecycle), the Bay Area Air Quality Management District (BAAQMD), County of Marin: Environmental Health Services (EHS), Community Development Agency (CDA) and Department of Public Works (DPW). CEQA is completed and approved for the drop off site.

The waste handling pick up program is coordinated with five West Marin equestrian facilities. West Marin Compost files for tax identification. Logo and website are developed. Extension is requested from USDA. Construction and compost production begins.

2012 Compost is sold! Research partnership is formed with Marin Carbon Project and UC Berkeley to determine carbon sequestration rates on Matin County rangelands. Compost at the Commons Workshop is held.

All WMCP budgets were exceeded during the life of the grant and shortfalls were compensated with new funding sources. The original WMCP budget provided for a fully operational facility at the completion of the grant. The compost operator was to contribute 5343,100 in construction labor and equipment. The West Marin Compost Coalition committed to 5110,000 in consulting expertise. Other partnering agencies and organizations pledged 5101,000 in outreach, education and permitting assistance. (5554,100K in contributions + 5570K USDA = 51.1M)

In the development of the.project, revisions were made to the original budget which was attributed to the unforeseen site preparation expenses including drop off site relocation, purchase of the mattresses, water development and the purchase of air quality compliant equipment. Anticipated budget shortfalls caused the Marin RCD Board to look into additional funding through the County of Marin. The County had supported the project, particularly in terms of the green waste diversion meeting its zero waste strategy. Supervisor Steve Kinsey proposed having the shortfall funded by Redwood Empire Disposal (RED). RED is a wholly owned subsidiary of the Ratto Group of Companies and holds a franchise agreement with the County of Marin. The agreement was up for renewal and would offer the project financing which would be passed down to its customers by way of rate increases. The average monthly bill would increase by 5.83 and be used for the compost project financing. This financial option succeeded and provided the project with the additional capital necessary.

The final WMCP budget resulted in 5409,392 in matching funds, provided by the compost operator. 5420K was provided by Redwood Empire Landfill and the County of Matin. West Marin Compost Coalition contributed 5110K. The remaining match was provided by partner agencies and organizations. The USDA NRCS CIG grant provided 5570K. The total budget of the project exceeded 51.6M.

Project Innovation & Benefits

The WMCP is unique in bringing together a wide array of community, environmental and agricultural issues while addressing them systematically with a single solution of composting.

1) *Economic Viability.* Local dairies have imported bedding material from off farm for decades, often in the form of beach sand. The source of this very desirable bedding material was recently lost to the farming community, due to changing environmental regulations. Local dairies have been forced to import expensive bedding materials from the Central Valley of California, primarily rice hulls and almond shells, with increased trucking costs and GHG

emissions associated with long distance hauling. WMCP is now producing bedding material for the partner dairy on-site, reducing the cost of bedding material and associated trucking. Consequently, the cost of spreading wet dairy manure is reduced. All liquid manure is now transferred to gravity separators, where the solids are diverted to the compost operation and the liquid is returned for reuse to flush the loafing barn. All need for liquid manure spreading has been eliminated. Manure handling responsibilities are now handled by WMCP, reducing labor costs to the dairy. The spreading of dry compost is significantly less expensive than spreading of wet manure; the lighter material also facilitates a more even and widespreaddistribution of the cQmpost, as compared to the spreading of wet manure, which is limited to relatively mild slopes.

Finally, pasture production is increased which benefits the partner dairy. Compost amended soils hold more water than non-amended soils and produce more forage for livestock (See Appendix C: Research: Effects of Organic Matter Amendments on Net Primary Productivity and Greenhouse Gas Emissions in Annual Grasslands as printed in Ecological Society of " America). This is particularly significant for our regional water and forage- limited dairies, particularly our organic dairies, which are subject to stringent pasture access requirements.

2) *Watershed Health.* By combining organic waste streams from three community sectors: dairy, equestrian and green waste producers, WMCP significantly reduces the amount of raw manures spread within local watersheds. In addition, a reduction in truck miles travelled on local roads, with associated GHG emissions, has been achieved by providing a local alternative to distant regional waste handling facilities. By capturing most of the local equestrian manure and soiled bedding via the Project's roll-off dumpster service, multiple potential point sources of water pollution have been eliminated.

WMCP also offers benefits to pasture management. By blending nutrient and water-rich manure with drier, carbon-rich materials and composting the mix at thermophilic (>131F) temperatures, pathogens and weed seeds are destroyed (See Appendix B: Lab Results & Windrow Temperature Records) reducing the need for pasture weed management. Additionally, through composting, nutrients are bound in complex organic compounds and thus less readily leached from the final material than from unprocessed manure, reducing risk to surface waters and regulatory consequences associated with that risk.

3) *Fuels Reduction.* By providing a local green waste composting facility, seasonal fire fuel reduction efforts have been significantly facilitated. Rather than having to haul ground green waste materials collected as part of seasonal fuel reduction efforts long distances for disposal, green materials can now be processed less than one mile from the collection

point, at the WMCP green waste drop off facility. Trucking costs, GHG emissions and labor associated with this seasonal Fire Safe Marin program have thus been significantly reduced.

4) *Carbon Sequestration.* Parallel with WMCP development, the question of carbon sequestration in agricultural soils has emerged as a central issue within the local, regional, national and global climate change discussion. WMCP is now partnering with the Marin Carbon Project to demonstrate the efficacy of compost applications on grazed rangelands to sequester carbon in soils in Marin County and beyond. The emergence of the California Carbon Market presents opportunities for compost producers and users to receive a degree of financial remuneration for this soil quality enhancing practice. This local agricultural-community composting facility serves as a model for other regions that may be seeking integrated solutions to similar regional problems.

Operational Adjustments

The Lafranchi Dairy provided approximately five acres of productive pastoral land for the development of the compostpad and associated activities which included new pasture fencing, improved access roads, cattle guards and newly constructed gravity manure separators. The separators have significantly improved flush water quality for the dairy loafing barns and eliminates the dairy from having to capture and pump roof runoff for next year's flush water. As a result the water loss to spreading of manure slurry has been eliminated. By producing and spreading the dry compost as an alternative to the wet manure slurry, the cost has been reduced. Another operational adjustment to the producer is the season by which spreading typically occurs since the season for compost spreading is significantly longer than the season for slurry application. Dry compost does not pose the water quality risk of wet manure which allows for the lengthier season of application.

Media, Marketing & ***Outreach***

Outreach was the first order of business for WMCP and it was determined it was necessary to describe the project to the Nicasio community considering the proposed drop off site was to be located next to the town. A Landowners Association meeting was convened where the project was described to the community. The Tomales Bay Association was also provided a presentation on the benefits of the project and was well received (See Appendix D: Nicasio Landowners Association & Tomales Bay Association Presentations). The project received media attention throughout the duration of the project including recognition from local Assemblyman Jared Huffman and Bay Nature Magazine. Local newspapers and radio covered its progress extensively (See Appendix E: Media Newspapers, Magazines and Recognition).

A website is already being used as an informational and marketing tool (See Appendix F: West Marin Compost website). WMCP is also listed on partner websites such as www.growninmarin.org and www.marinrcd.org to inform the public of the project. WMCP has hosted a community compost education day in the town square and donated compost to the local San Geronimo School Community Garden for educational purposes.

The project has purchased a bagger and intends to market a bagged organic compost product. There has been no formal market analysis conducted on this specific product, although informal surveys and reports suggest there is a demand for local organic compost. Preliminary research was conducted b~) Marin Organic and other project partners. Lists of available organic compost companies were compiled and found to be available at a great distance and/or cost. A small . local compost facility located elsewhere in the county has consistently created compost for a few year.s with a product in high demand. Additionally due to anticipated demand, during the WMCP planning phase, another start-up compost company initiated operations at a local dairy and is operating successfully. Informal surveys and research anticipate there will be vigorous demand for the product, which is expected to market at a competitive price.]’he expectation is that bagged sales will provide a significant portion of operating revenue going forward. The product is certified as Organic Input Materials by the California Department of Food and Agriculture, which has recently enabled WMCP to develop a marketing program, and move forward with the printing of retail compost bags (See Appendix F: West Marin Compost website for Nicasio Blend bag design). It is anticipated that bagging and marketing of the product will occur by early 2013. WMCP’s target audience will be focused on local retail outlets in the surrounding community.

Discoveries & Lessons Learned

Permits and Planning. WMCP was proposed as a construction project; however complexities with planning and permitting authorizations were unknown. Many obstacles presented themselves along the way including zoning restrictions associated with the drop off site, California Air Resources Board/Bay Area Air Quality District permits, California Environmental Quality Act approvals, AB32 emissions requirements for equipment/engines and community disapproval to perceived traffic/noise/smells. Fortunately, the County of Marin provided significant financial assistance in completing these critical steps. Many of these requirements could not have been anticipated given the very recent environmental changes made through local and state government for compost facilities and operational equipment.

Waste Stream Deficits. WMCP is working as designed although it has been observed that community utilization of the green waste drop off component is not as expected. This may be attributed to the presence of previously unknown and unl~ermitted green waste drop off sites in the surrounding area. Because these sites are not permitted, it is anticipated they will be eliminated in the near future. Though anticipated green waste from the local community was underestimated, an unexpected volume of material was made up from fire and fuel reduction and public works sources. Also unanticipated was a seasonal (dry season) decline in available manure from the dairy. This seasonal deficit has enabled import of manure from other local dairies, allowing a widening of the area of beneficial influence of the project.

The project is developing as planned and there are no revisions or any major modification in the project design. However, if the project were to start over today a comprehensive marketing study would have been conducted at the beginning of the project. Additionally, project planning and permitting would have been included in the development of the project.

VI. Q ality Assurance:

WMCP is comprised of a community drop off site and compost facility located at adjacent properties along the same road. The drop off site is located at a highly accessible site on Nicasio Valley Road. To guarantee quality control, all incoming loads of green material are inspected for contaminants prior to acceptance. Material is then ground up and transported to the compost facility on a weekly basis.

The compost facility is located one mile away at the Lafranchi Dairy, an active commercial organic dairy. Manure and bedding from ten designated equestrian facilities are collected weekly in roll-out bins and combined with dairy manure and green material at the dairy. Approximately 5 acres at the Lafranchi Dairy have been designated to the Compost Yard which includes: freshwater pond, a manure pond, manure separators, a mixing pad, active windrows and finished windrows (See Appendix A: Site Maps). Windrow temperatures are monitored daily during the pathogen reduction phase. The thermometers require periodic calibration, using ice water to set adjustable thermometers to 32°F. All finished material is subjected to a bioassay to evaluate impacts on germination and plant growth.

To ensure that compost and precision level of measurements are sufficient, sampling is conducted in accordance with standard compost sampling procedures required by California Department of Food and Agriculture (CDFA), CAL Recycle and Federal USDA regulations (See Appendix E: Lab Results and Windrow Temperature Records). Maintaining temperatures of 131 F or higher for 15 days or more (thermophilic composting) eliminates virtually all pathogens and noxious weeds. Following the sampling design, subsamples are collected systematically throughout the active compost piles. Once the samples are collected they are combined and mixed. A composite sample is taken and sent to a certified laboratory within 4 hours of sampling where they are evaluated for pathogens, metals and C/N ratios. When the sample analyses are completed, with chain of custody maintained throughout, the final results are reported electronically. To guarantee quality control, all samples are taken identically and analyzed by certified laboratories to determine if detection limits have been exceeded. No statistical analyses have been conducted on the final project data although; the data is reviewed by local and state regulators (Marin Environmental Health and CDFA) on a quarterly basis.

The following is a list of deliverables and products that were anticipated from the project in the planning stage followed by actual deliverables produced in year one. It is anticipated that waste streams will increase in years to follow thereby increasing results:

- **12,000 yrds^3 of dairy manure composted to a weed and pathogen free state annually.** Actual dairy manure processed by the project in year one: approximately 4000 cubic yards of weed free, Organic Input Materials certified by the California Department of Food and Agriculture.
- **12,000 yrds^3 of equestrian waste annually processed to a weed and pathogen free state.** Actual equestrian waste processed by the project in year one: approximately 5000 cubic yards from five local equestrian facilities.
- 12,000 **yrds^3 of green waste diverted from landfills and/or illegal roadside dumping.** Actual green waste diverted to composting year one: approximately 6000 cubic yards.
- 20,000 **yrds^3 of compost produced annually for bedding and soil quality enhancement.** Actual compost produced year one: approximately 8000 cubic yards.
- Approximately 7,000 **tons of carbon sequestered in Marin's agricultural soils annually.** Actual carbon sequestered as compost in year one: approximately 0.315 x 4000 tons = 1260 tons C or 4624 tons CO_2e per research conducted in accordance with UC Berkeley and the Marin Carbon Project (See Appendix C: Research of Organic Matter Amendments on Net Primary Productivity and GHS Emissions in Annual Grasslands).
- **The establishment of a community green waste drop off and composting facility serving West Marin's agricultural, wildland and rural residential components.** Though not yet operating at full capacity, this project component is up and running as planned. It is anticipated the facility will be fully operational in two years.
- **Improved water quality in tributaries to Tomales** Bay. Although we do not have specific data to support this objective, water quality monitoring conducted by the Tomales Bay Watershed Council and County of Matin on a

watershed scale suggests water quality trends remain steady. There is neither dramatic improvement nor decline.

Educational materials focused on the management and use of compost and organic **wastes for dairy bedding and soil and water quality improvement.**
A web site is up and running while marketing materials are under development. UCCE's www.~rowninmarin.or~ and Marin RCD's www.marinrcd.or~ have both published informational pieces about the project.

VIII. Conclt~sions and *Recommendations:*

While some fine tuning of the project remains to be accomplished over the coming year, the fundamental project principles have proven to be sound. The project's priority to improve on-farm efficiency by reducing hauling and equipment maintenance costs associated with the importation and use of sand as a bedding material, enhancing forage production via improved soil quality and water holding capacity and reducing costs associated with the hauling and spreading of wet manures was accomplished.

In addition, during the 5 year period of project development, the role of organic matter in general, and compost in particular, in sequestering atmospheric CO_2 as soil carbon has become increasingly pertinent. California has identified the need for up to 250 new compost facilities to address the 35 million tons of organics landfilled in the state each year. The role of decentralized, on-farm composting in meeting the need for environmentally sound manure handling and organic waste recycling capacity is being increasingly recognized. The Marin Carbon Project research results, which have emerged contemporaneously with development of WMCP, support this concept for climate change mitigation and as a water conservation and forage enhancement strategy (See Appendix C: Research of Organic Matter Amendments on Net Primary Productivity and GHS Emissions in Annual Grasslands).

Our hope is that as compost application and carbon sequestration is moved to the forefront of environmental mitigation options, farmers will begin to use this technology and be supported in the startup of on farm compost facilities. A soon to be released report directed by our partnership entitled, "Economic Analysis of Feasibility and Potential to Monetize Compost Additions to Rangeland Soils" identifies cap and trade as a viable option in the next 5 years and California Environmental Quality Act mitigation banking as being a viable option now.

Farmers must be supported with technical and financial assistance to ready themselves for these new options. The WMCP and MCP partnership will be developing such a structure with plans to follow up with the implementation of carbon farm action plans centered on compost application. A structured protocol and verification framework will be developed for duplication on a grander scale.

There is significant interest regionally, statewide and nationally in the potential role of Compost in the climate change and agricultural sustainability equations. In December 2012, project representatives met with the State of California CALRecycle senior staff and Speaker of the California State Assembly, John Perez to initiate discussions regarding implementation at a state level. WMCP is already proving to be the foundation for change that will benefit soil health, water quality, climate conditions and agricultural viability.

Earth knows no desolation.
She smells regeneration in the moist breath of decay.
- *George Meredith*

Appendix A

Green Waste Drop-off & Compost Site Locations


West Marin Compost Yard
Finished Windrows
manure separators
Mixing Pad
Active Windrows
Gate
Manure Pond
Fresh Water Pond
© 2012 Google
Google earth
Imagery Date: 5/6/2012
1993
38°05'10.70" N 122°42'26.91" W elev 239 ft
Eye alt 1623 ft


West Marin Compost Yard
Nicasio Valley Road
Entrance, Lafranchi Organic Dairy
© 2012 Google
Google earth
Imagery Date: 5/6/2012
1993
38°04'58.34" N 122°42'38.34" W elev 299 ft
Eye alt 5627 ft

Appendix B

Lab Results & Windrow Temperature Records

tical Sciences

February 24, 2012

Jeff Creque
908 Western Ave.
Petaluma, CA 94952

Dear Jeff,

Enclosed you will find Analytical Sciences’ final report 2021402 for your Compost Test project. An invoice for this work is enclosed.

Should you or your client have any questions regarding this report please contact me at your convenience. We appreciate you selecting Analytical Sciences for this work and look forward to serving your analytical chemistry needs on projects in the furore.

Sincerely,

Analytical Sciences

Michele Peters

Laboratory Manager

P.O. Box 750336
Petaluma, CA 94975-0336
Telephone: (707) 769-3128

110 Liberty Street
Petaluma, CA 94952

Analytical Sciences

Report Date: February 24, 2012

Laboratory Report

Jeff Creque
908 Western Ave.
Petaluma, CA 94952

Project Name: **Compost Test**

Lab Project: 2021402

This 3 page report of analytical data has been reviewed and approved for release.

Michele Peters

Laboratory Manager

P.O. Box 750336
Petaluma, CA 94975-0336
Telephone: (707) 769-3128

110 Liberty Street
Petaluma, CA 94952

Fecal Coliform

Lab#	Sample ID	Compound Name	Result (MPN/g)		RDL (MPN/g)
2021402-01	W. Matin Compost - 'F & S'	Fecal Coliform	86	DW	3

Date Sampled:	02/14/12	Date Analyzed:	02/17/12	QC Batch: B010289
Date Received:	02/14/12	Method:	SM 9221	

Percent Moisture

Lab#	Sample ID	Compound Name	Result (% by Wt.)	RDL (% by Wt.)
2021402-01	W. Marin Compost - 'F & S'	% Moisture	. 41.6	0.10

Date Sampled:	02/14/12	Date Analyzed:	02/15/12	QC Batch: B010267
Date Received:	02/14/12	Method:	SM 2540 B	

Notes and Definitions

DW	Results are calculated on a dly weight basis, -
RDL	Repolnting Detection Limit
ND	Analyte NOT DETECTED at or above the reporting detection limit (RDL)
RPD	Relative Percent Difference
NR	Not Reported

Please Note: California Department of Health Services recommended drinking water standards are as follows:

Arsenic (10 ug/g)
Iron (300 ug/L)
Manganese (50 ug/L)
Nitrate (45 rag/L)
Lead (15 ug/L)
Total Coliform (<1 MPN/100 mL)

Analytica~ Sciences
P~O. ~ox 755336, ~e~aluma, CA 94~75-0356
t"~0 Liberty S~reet, P,e~lum~, CA 9~952

Fax (707) 769~093

CHAIN OF CUSTODY

LAB ~ROJSCT NUI%~BER: 2021402

CLISNT~S PROJECT NAr¢,E:

CLIENT INFORMATION

CLIENT'S Jeff Cregue

ADDRESS: 908 Western Ave

STATIC, ZP Petaluma CA 94

707-765-1059

FAX #:

EMAIL ADDRESS:

TURNAROUND TI,~E l,check o,oe..)

SA~E DAY | 72 HouRs
24 HOU[~S | 50AYS
48 HOURS

PAID—CHECK # ______
PAID—CASH: ______
BALANCE DUE: ______

COC 1 OF

Sonicnet

ITEM	CLIENT SAMPLE I.D.	DATE SAMPLED	T ~,~. E MATRC<	# COKT.	PRESV. YES/NO	Bac-T / E.Coli	Nitrate	Arsenic—GFF	Lead—GFF	VOC's 524.2 / 8260 LL	Manganese	Iron	pH	EC	Salmonella	Fecal Coliform	% Moisture
1	W. marin compost	2/14/12	Compost												✓	✓	✓
2	'F+S'																
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	

CC ~,t~IENT5

T

$1GNA TURES

RELINQUISHED BY: [signature]
SIGNATURE
2/14/12 DATE 12 Pm TIME

R.ECEr,,ED ~Y LABCP~.TORV:
/14/ DATE 1200 TIME

BioVir Laboratories, Inc

NELAC #05234CA
EPA ID# 01401, CA-ELAP #t79

6~5 Stone Road Umt 6 ¯ Benlcia, CA 94510. (7'07) 7475906 ¯ t 800 GtARDtA ¯ FAX (707) 747-!751 . WEB ,,*.~v~.,,' biovi~ corn

REPORT NO.: 120230 "
PAGE NO.: **1 of 2**
CLIENT: AnalyticalSciences
ADDRESS PO, Box 750336
Pef:aluma, CA 94975
CLIENT NO ANA008 CLIENT PO: 2021402

ASSAY RESULTS:

Test: 1682 Salmonella MSRV **Method: EPA1682**

BioVir #	Sample ID	Site	, Analyte	**Result**	Units
120230-001	W. Matin Compost **'F & S'**		Salmonella spp,	**<0,4**	tVIPNI4 g TS

Collector: Jeff Cteque CotlectDate 2t 14t2012 CollectTime i2:00:00 PM
ReceiveDale 2/15/2012 !0:05:00AM Matrix: Biosoilds Ter;]p 3,4
Volume ~56 g Analysis Sta~ Da~e: 2!15/12 Analysis Sta[t Time: 1100
Analys~ JTmscott Analys~s End 2121/2012

Comment

Test: Total Solids **Method:**

BioVir #	Sample ID	Site	Anatyte	Result	**Untts**
120230-001	W. Marin Compost 'F & S'		Total Solids (%)	59.5	**% Total Solids**

Collector~ ,Jeff Creque CollectDate 2;}4/20t2 CollectTime: 12:00:00 PM
ReceiveDa~e 211512012 10:0500AM Matrix: Biosoilds Temp 34
Volume: 156 g Analysis Stad Date 2/I5/12 AnaiyMs Start Time: 1715
Analyst: MPeaslee Analysis End: 2t~6/2012

Commenl

Ana]ytJca] Sciences
Box 750336, Petalurna, CA 94975-0336
1~10 Liberty Street~ Peta~uma, CA 94952
(707} 769-3128
Fax (707) 769-8093

CHAIN OF CUSTODY

OPY

SUBCONTI~CT LAB: Bio Vir
AS PROJECT NAME Soil Testing
AS PROJECT NU~v~BER." 2021402

COMPANY NAME: ANALYTICAL SCIENCES

ADDRESS: **P.O.** E];OX 750336

PETALU~VIA, CA 94975-0336

CONTACT: MARK VALENT~NI

PHONE#: (707) 769-3128

FAX #: (707) 769-8093

COOLER TE~PERATU RE

°C

SAME DAY **24 HOURS**

48 HOURS **72 HOURS**

5 DAYS **NORMAL** X

COC

PAGE OF

ITEM	CLIENT SAMPLE I.D.	DATE SAMPLED	TI?~IE	MATRIX	# CONT.	PRESV. YESINO		COMMENTS	LAB SA~APLE
1	W. Marin Compost	2/4/1x	1200				X		2021402-01
2	'F+S'								
5									
7									
8									
~0									

~ ~UtSHED BY"I f. RECEIVED E~Y LABORATORY:

S)~ATURE " DATE Ti~,~E SIGNATUFLE DATE TIME

Sciences

February 28, 2012

Jeff Creque
908 Western Ave.
Petaluma, CA 94952

Dear Jeff,

Enclosed you will find Analytical Sciences' final report 2021404 for your Compost Test project. An invoice for this work is enclosed.

Should you or your client have any questions regarding this report please contact me at your convenience. We appreciate you selecting Analytical Sciences for this work and look forward to sel~cing your analytical chemistry needs on projects in the furore.

Sincerely,

Analytical Sciences

M Pete

Michele Peters

Laboratory Manager

P.O. Box 750336
Petaluma, CA 94975-0336
Telephone: (707) 769-3128

110 Liberty Street
Petaluma, CA 94952

~tical Sciences

Report Date: February 28, 2012

Laboratory Report

Jeff Creque
908 Western Ave.
Petaluma, CA 94952

Project Name: **Compost Test**

Lab Project: 2021404

This 5 page report of analytical data has been reviewed and approved for release.

Michele Peters

Laboratory Manager

P.O. Box 750336
Petaluma, CA 94975-0336
Telephone: (707) 769-3128

110 Liberty Street
Petaluma, CA 94952

Total Phosphorus

Lab#	Sample ID	Compound Name	Result (mg/kg)		RDL (mg/kg)
2021404-01	W, Matin Compost -	Phosphorus	1100	DW	170

Date Sampled:	02/14/12	Date Analyzed:	02/16/12	QC Batch: B010265
Date Received:	02/14/12	Method: ’	EPA200.7	

Metals

Lab#	Sample ID	Compound Name	Result (mg/kg)		.RDL (mg/kg)
2021404-01	W. Marin Compost -	Arsenic (As)	1,3	DW	1,0
		Cadmium (Cd)	ND	DW	0,50
		Chromium (Cr)	27	DW	1,5
		Copper (Cu)	79	DW	1,0
		Lead (Pb)	6,7	DW	3,0
		Nickel (Ni)	36	DW	2,0
		Potassium (K)	4400	DW	50
		Selenium (Se)	ND	DW	5,0
		Zinc (Zn)	69	DW	5,0

Date Sampled:	02/14/12	Date Analyzed:	02/15/12	QC Batch: B010265
Date Received:	02/14/12	Method:	EPA 6010B	

Mercury

Lab#	Sample ID	Compound Name	Result (mg/kg)	RDL (mg/kg)
2021404-01	W, Marin Compost-	Mercury (Hg)	ND	0,10

Date Sampled:	02/14/12	Date Analyzed:	02/23/12	QC Batch: B010266
Date Received:	02/14/12	Method:	EPA 7471A	

I

Conductivity

Lab#	Sample ID	Compound Name	Result (gS/cm)		RDL (gS/cm)
2021404-01	W. Marin Compost -	Conductivity	1400		5.0

Date Sampled: 02/14/12 Date Analyzed: 02/15/12 QC Batch: B010293

Date Received: 02/14/12 Method: SM 2510 B

I

Anions

Lab#	Sample]D	Compound Name	Result (mg/kg)		RDL (mg/kg)
2021404-01	W. **Marin Compost -**	Nitrite as N	2.3	DW	0.34
		Nitrate as N	0.61	DW	0.34

I Date Sampled: 02/14/12 Date Analyzed: 02/14/12 QC Batch: B010287

Date Received: 02/14/12 Method: EPA 300.0

TKN

Lab#	Sample ID	Compound Name	Result (mg/kg)		RDL (mg/kg)
2021404-01	W. Matin Compost -	Total Kjeldahl Nitxogen	7600	DW	2200

Date Sampled: 02/14/12 Date Analyzed: 02/17/12 QC Batch: B010291

Date Received: 02/14/12 Method: SM 4500-Norg C

Total Nitrogen as N

Lab#	Sample ID	Compound Name	Result (mg/kg)		RDL (mg/kg)
2021404-01	W. **Matin Compost -**	Total Nitrogen as N	7603	DW	2,50

Date Sampled: 02/14/12 Date Analyzed: 02/17/12 QC Batch: B010291

Date Received: 02/14/12 Method: EPA/SM - summation

I

Percent Moisture

Lab#	Sample ID	Compound Name	Result (% by Wt.)	RDL (% by Wt.)
2021404-01	W. Marin Compost -	% Moisture	41.8	0.10

Date Sampled:	02/14/12	Date Analyzed:	02/15/12	QC Batch: B010267
Date Received:	02/14/12	Method:	SM 2540 B	

Notes and Definitions

DW	Results are calculated on a dry weight basis.
RDL	Reporting Detection Limit
ND	Analyte NOT DETECTED at or above the reporting detection limit (RDL)
RPD	Relative Percent Difference
NR	Not Reported

Please Note: California Department of Health Services recommended drinking water standards are as follows:

Arsenic (10 ug/L)
Iron (300 ug/L)
Manganese (50 ug/L)
Nitrate (45 mg/L)
Lead (15 ug/L)
Total Coliform (<1 MPN/100 mL

P.O. Box 750336
Petaluma, CA 94975-0336
Telephone: (707) 769-3128

Analytical Sciences
P.O.IBox 750336, Petaluma. CA 94975-0336
Liberty Street~ Petaluma, CA 9~952

Fax {7D7) 769-80~3

CHAIN CUSTODY

LAB PROJECT NU~4:BER: 2021404

CL EN7'S PROJECT NAME:

CUEN T INFORMA TfON

CLIENT'S NAME; Jeff Creque

ADDRESS: 908 Western Ave

CI-Pf, STATE, Z!P Petaluma CA 94952

PHO~;E #: 707-765-1059

F~x #:

E?~IAtL ADDRESS: EQUE@sonic.net

TUR~'~AROUND T~ME (check one)

SAM E DAY	72 HOURS
24 HOURS	5 DAYS
4g HOURS	NORr4AL

PAID

PAID'--CAsH: i

COC

PAGE OF

ANALYSIS

ITEM	CLIENT SAMPLE I.D.	DATE SAMPLED	TIME	Bac-T / E.Coli	Nitrate	Arsenic—GFF	Lead—GFF	VOC's 524.2 / 8260 LL	Manganese	Iron	~~pH~~ 90 Moisture	EC	Cd, Cr, Cu, Hg, Ni, Se, Zn	Total N	P2O5 / K2O (Phos) (K)	COMMENTS	LAB SAi~PLE #
1	W. Marin	2/14/12	12PM			✓	✓				X	✓	✓	✓	✓	2021404-01	
2	compost																
3	(metals)																
4																	
~0																	
11																	

SIGNATURES

RELINQUISHED BY: [signature]
SIGNATURE

2/14/12 12Pm
DATE TIME

RECEIVED BY LABORATORY: [signature]
SIGNATURE

2/14/12 1200
DATE TIME

110 Liberty Street
Petaluma, CA 94952

West Marin Compost Record

Batch #: 1
Date of assembly: 9/21/11
Initial Quantity (cY): end ofprp (CY) 468
Initial comments:

Mixture- 4 green waste, 5 manure, 3 manure pond sludge

Date	**H20** (y/n)	Turn (fin)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
9/29/11	n	n	140	120	135	142	148	
9/30/11	n	n	150	158	123	130	140	
10/3/11	n	n	143	117	118	150	140	
10/15	D	y	147	118	120	148	140	
10/17	n	n	140	122	120	138	140	
10/18	n	n	145	127	139	145	138	
10/20	11	n	**140**	**133**	**143**	**150**	**140**	**begin prp**
10/21	n	n	143	141	148	145	140	

10/22	n	y	148	145	145	148	142	
10/24	n	n	145	143	144	152	140	
10/25	n	Y	155	145	153	150	142	
10/27	n	n	152	149	152	148	151	
10/28	n	y	14S	143	141	143	145	
10131	n	Y	147	141	148	141	135	
11/1	n	n	136	133	140	135	136	
11/2	n	n	133	134	136	133	135	
11/3	n	y	132	133	135	137	133	
11/7	n	n	140	137	132	132	135	end of prp; 11/4 fight showers, 11/5 rain
11/14	n	n	138	134	135	135	125	
11/28	n	y	136	135	135	137	122	batch 1 & 2 conbined
12/5	n	n	122	128	122	117	125	temps for batch 1 & 2
12/12	n	n	137	145	146	153-	147	
12/19	n	n	137	142	136	139	130	
12/27	n	n	143	140	145	137	i35	
1/4	n	n	143	140	142	144	138	
1/9	n	n	140	140	137	142	138	
1/17	n	n	135	133	135	137	137	

West Marin .Compost Record

Batch #: 2
Date of assembly: 9/23/11
Initial Quantity (CY): end ofprp(CY) 4S7
Initial comments:

mixture- 4 green waste, 5 manure, 3 manure pond sludge

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
9/29/11	n	n	150	145	125	120	115	
9/30/11	n	n	125	120	140 "	108	9S	
lO/3/11	n	n	142	140	125	120	110	
10/15	n	y	140	137	135	12S	124	
10/17	n	r~	141	140	140-	128	130	
10/18	n	n	145	135	130	142	140	begin prp
10/20	n	Y	141	139	151	149	156	
10/21	n	n	145	148	135	133	138	

10/22	n	Y	146	140	140	142	140	
10/24	n	n	135	140	139	141	138	
10125	n	y	148	145	140	145	145	
10/27	n	n	151	146	148	149	142	
10/28	n	y	140	148	t48	140	143	
10/31	n	Y	139	1~43	135	139	135	
11/1	n	n	135	135	137	133	135	
11/2	n	n	140	140	135	137	135	
11/3	n	n	145	134	135	137	137	
11/7	n	y	140	135	138	145	146	11/4 showers, 11/5 rain
11/14	n	n	138	140	135	137	138	end prp
11/28	n	y	135	133	135	143	128	batch 1 & 2 combined;
								11/29 and on, see batch #1

West Marin Compost Record

Batch #: 3
Date of assembly: 9/26/11
Initial Quantity (cY): 412 - (296 cY that became batch 9)= 116
Initial comments:

mixture- 2 green waste, 4 manure, 3 manure pond sludge

removed some of this batch and called it batch #9

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
11/1	n	n	132	119	143			
11/2		Y	137	133	137			
11/3	n	n	131	102	116			
11/4	n	n	137	117	118			light showers
11/7	n	n	140	128	137			1115 rain
11/8	n	y	136	141	140 "			begin prp
11/10	n	y	142	133	139			
11/11	n	n	140	132	134			rain

11/13	n	y	137	133	133			
11114	n	n	135	132	133			
11/15	n	y	136	133	132			
11/17		y	136	135	135			
11/18	n	n	132	133	134			
11/21	n	n	133	132	132			11/20 rain
11/22	n	n	134	134	135			end prp
11/28	n	Y	128	123	127			combined batch 3 & 10
12/5		n	123	118	126	118	119	temps for batch 3 & 10
12/12	n	n	125	133	127	132	135	
12/19	n	n	125	123	130	131	128	
12/27	FI	n	132	133	128	133	138	
1/4	n	n	132	132	133	134	136	
1/9	n	n	130	130	131	133	134	
1/17	n	n	130	125	129	130	132	

West Marin Compost Record

Batch #: 4
Date of assembly: 9/30/11
Initial Quandty (CY): 2S4
Initial comments:

mixture- 1 green waste, 3 manuer, 2 sludge

removed some of this batch and called it batch #10

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
11/1	n	n	127	102				
11/2	n	Y	123	116				turned to dry
11/3	n	n	110	93				
11/4	n	n	120	117				light showers
11/7	n	n	129	117				11/5 rain
11/8	n	n	122	117				
11/10	n	n	128	121				
11/11	n	n	117	119				rain

11/13	n	n	123	.115	
11/14	n	n	120	118	
11/15	n	n	125	126	
11/17	n	n	126	123	
11/18		n	120	131	showeres
11/28		n	118	115	11/20 rain
12/5		n	140	135	added manure to cover pile
12/6		n	138	133	
12/7	r~	n	135	134	
12/8	n	y	135	150	
12/9	n	n	133	134	
12/10	n	n	135	136	
12/11	n	Y	133	135	
12/12	n	n	134	140	
12/13		n	135	137	
12/14					dod not work, going to spread on dairy

West Marin Compost Record

Batch #: 5
Date of assembly: 10/4/11
Initial Quantity (cY): 211
Initial comments:

mixture- 1 green waste, 5 manure, 2 equestrian

Date	H20 (y/n)	Tu rn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
10/17	n	n	100	95				
10/18		n	96	90				
10120		n	109	91				
10/21	n	n	115	93				
10/22		n	118	92				
10/24		n	108	93				
10/25		n	110	100				
10/27	n	n	125	100				

I 0/28	n	n	105	102	
10/31	n	Y	120	100	turned to dry out pile
11/1	n	n	125	115	
11/2	n	y	133	132	
11/3	n	n	102	100	
11/4	n	n	131	101	light showers
11/7	n	n	145	122	11/5 rain
11/8	n	Y	150	133	
11/10	n	y	134	132	
11/11		n	133	132	rain
11/13	n	n	128	120	
11/14	n	n	131	118	
11/15	n	n	132	125	
11/17	n	n	133	117	
11/18	n	.n	132	118	showeres
11/21	n	n	130	120	11/20 rain
11/28	n	n	123	117	
12/5	n	n	128	118	
12/6	n	n	135	115	

12/7	n	r]	130	117	
12/8	n	n	135	115	
12/9		n	123	111	
12/10		n	122	114	
12/12		n	125/	112	
12/14					did not work, going to spread on dairy

West Marin Compost Record

Batch #: 6
Date of assembly: 10/18/11
Initial Quantit~ (cY): 471
Initial comments:

mixture- 1 green waste, 3 manure, 2 equestrian waste

manuere was a little wet

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
10/20	n	n	88	80	95			
10/21.	n	n	98	105	100			water draining out sides
10/22	n	n	85	93	103			
10/24	n	n	98	88	105			
10/25	n	n	85	100	111			
10/27	n	n	105	129	118			
10/28	n	n	93	9O	105			
10/31	n	Y	92	90	120			turned to dry

11/1	n	n	110	132	121			
11/2	n	n	120	133	140			
1113	n	n	108	131	133			
11/4	n	n	115	120	132			light showers
11/7	n	n	133	135	155			bigin prp. 11/5 rain
11/8	n	y	140	142	144			
11/10	n	Y	134	136	139			
11/11	n	n	132	141	136			rain
11/13	n	y	134	140	134			
11/14	n	n	132	133	133			
11/15	n	Y	132	132	135			
11/17	n	y	133	135	134			
11/18	n	n	131	133	132			shower's
11/21	n	n	133	132	135			11/20 rain
11/22	n	Y	132	132	132			
11/28	n	n	133	131	138			end prp
12/5	n	n	125	135	139			
12/12	n	n	128	124	135			
12/16	n	Y	129	117	125	125	128	

West Marin Compost Record

Batch #: 7
Date of assembly: 10/21/11
Initial Quantit~ (cY): 421
Inidal comments:

mixture- 2 green waste, 4 manure, 2 equestrian waste

manure coming out of separator pits is drier than previously

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
10/25	rl	n	117	108				
10/27		n	135	132				
10/28	n	n	125	123				
10/31	n	n	132	115				
11/1	n	n	132	133				begin prp
11/2	rl	n	136	135				
11/3	n	n	135	137				noiticed a little water draining out the sides
11/4	n	y	155	135				light showers

11/7	.n	n	150	134		11/5 rain
11/8	n	y	151	143		
11/10	n	y	135	134		
11/11	n	n	140	137		rain
11/13	n	y	135	136		
11/14	n	n	140	135		
11/15	n	n	150	138		noticed water draining out bottom
11/17	n	y	152	135		
11/18	n	n	153	133		showers
11/21	n	n	146	135		11/20 rain
11/28	n	n	132	135		end prp
12/5	n	n	128	125		
12/12	n	y	135	120		
12/19	n	n	138	135		
12/27		n	142	145	145	
1/4	n	n	148	143	145	
1/9	n	n	130	138	136	
1/17	n	n	118	119	125	
2/6	n	y	125	128	119	

West Marin Compost Record

Batch #: 8
Date of assembly: 11/1/11
Initial Quantity (cY): 263
Initial comments:

Mixture- 2 green waste, 5 manure

manuer is drier

3 little piles;

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
11/2/11		n	100	100	92			mixture is fluffy
1113/11		n	115	115	87			
11/4/11	n	n	117	105	97			light showers
11/7/11	n	n	132	140	137			11/5 rain; begin prp
11/8/11	n	n	140	136	138			
11/10	n	y	155	152	135			
11/11	n	n	144	148	140			rain
11/13	n	y	146	145	152			

11/14	n	n	151	150	155	
11/15	n	Y	147	149	158	
11/17	n	y	148	153	149	
11/18	n	n	143	140	150	showers
11/21		n	145	150	145	11/20 rain
11/22		y	140	152	149	
11/28	n	y	145	150	149	end prp; moved all 3 piles together
12/5	n	n	150	158	160	
12/12	n	n	159	155	156	
12/19	n	n	149	145	142 .	
12/27	n	y	147	145	146	batches 8 & 11 combined
1/4	n	n	152	148	145,	
1/9	n	n	149	140	143	
1/17	n	n	135	142	145	
2/6	n	y	137	138	130	
2/15-	n	n	155t	150	147	
2/22	n	n	130	135	130 '	
3/5	n	n	123	122	125	

West Marin Compost Record

Batch #: 9
Date of assembly: 9/26/11
Initial Quantity (CY): 296
Initial comments:

mixture- 2 green waste, 4 manure, 3 sludge

removed this batch from batch #3

Date	H20 (y/n)	Tu rn (y/n)	Temp 1	Temp 2	Temp 3	Temp- 4	Temp 5	Comments
11/1	n	n	116	118				
11/2	n	Y	100	117				turned to dry out windrow
11/3	n	n	105	104				
11/4	n	n	107	116				light showers
11/7	n	n	121	125				11/5 rain
11/8	n	n	121	127				
11/10	n	n	120	123,				
11/11	n	n	130	130				rain

11/13	n	n	129	125	
11/14	n	n	125	130	
11/15	n	n	118	120	
11/17	n	n	120	121	
11/18	n	n	120	124	showeres
11/21		n	117	120	11/20 rain
11/28	n	n	114	123	
12/5		n	133	136	added manure to cover pile
12/6	n	n	132	134	
12/7	n	n	133	134	
12/8	n	y	135	134	
12/9	n	n	135	135	
12/10	n	n	140	136	
12/11	n	y	142	135	
12/12	n	n	140	136	
12/13	n	n	138	135	
12/14					did not work, going to spread on dairy

West Marin Compost Record

Batch #: 10
Date of assembly: 9/30/11
Initial Quantit7 (cY): 339
Initial comments:

mixture- 1 green waste, 3 manure, 2 manure pond sludge

removed this batch from batch #4

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
11/1	n	n	145	141	142			begin prp
11/2	n	y	137	145	142			
11/3	n	n	135	138	134			
11/4	n	y	133	135	139			light showers
11/7	n	n	134	133	133			11/5 rain
11/8	n	Y	133	134	133			
11/10	n	Y	132	132	134			
11/11	n	n	134	133	133			rain

11/13	n	Y	132	132	133	
11/14	n	13	133	132	134	
11/15	n	Y	132	133	132	
11/17	n	n	133	134	133	
11/18	n	n	133	132	132	showers; end prp
11/21	Fl	n	125	130	129	11/20 rain
11/28	n	n	126	125	126	conbined batch 3 & 10
						see batch #3; 11/29 and on,

West Marin Compost Record

Batch #: 11

Date of assembly: 11/4/11

Initial Quantity (CY): 53

Initial comments:

mixture- 2 green waste, 5 manure

manure is drier

Date	H20 (y/n)	Turn (yln)	Temp I	Temp 2	Temp 3	Temp 4	Temp 5	Comments
11/7/11	n	n	136	142				11/4 got light showers, 11/5 rain; begin prp
11/8/11	n	n	149	141				
11/10	n	Y	153	140				
11/11	n	n	145	140				rain
11/13	n	y	148	143				

11/14	n	n	150	142	
11/15	n	Y	148	145	
11/17	n	y	150	143	
11/18	n	n	148	145	showers
11/21	n	n	150	158	11/20 rain
11/22	n	y	160	159	
11/28	n	y	145	152	
12/5	n	n	158	150	
12/12	n	n	150	152	end prp;
12/19	n	n	130	142	
12/27	n	Y	128	145	combined to batch 8, check batch 8 for temps
1/4	n	n	144	147	
1/9	n	n	145	146	
1/17	n	n	147	128	
2/6	n	Y	133	125	

West Marin Compost Record

Batch #: 12
Date of assembly: 12/8/11
Initial Quantity (cY): 172
Initial comments:

mixture- 2 equestrian, 5 manure

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
12/12	n	n	123	127	118	120	122	
12/13	n	n	120	130	121	121	135	noticed water draining out the bottom
12/14	n	n	124	137	124	135	136	
12/15	n	n	127	138	126	135	135	
12/16	n	n	136	138	136	142 "	143	more water draining out bottom. Big in prp
12/17	n	n	135	139	134	141	140	
12/18	n	n	136	138	134	142	138	
12/19	n	y	135	139	137	138	143	

12/20	n	n	145	134	144	138	139	
12/21	n	n	148	160	157	138	158	
12/22		Y	152	155	145	151	145	
12/23	n	n	149	154	149	155	147	
12/24		n	137	145	145	149	149	
12/26	n	Y	143	150	152	152	155	12/25 didn't come to work add one day to prp
12/27		n	133	158	155	158	153	
12/28	n	n	155	164	158	165	169	
12/29	n	Y	154	143	154	158	159	
12/30	n	n	148	146	136	143	140	
12/31	N	n	150	148	138	140	145	
1/2	N	y	152	145	143	148	155	1/1 didn't come to work add one day to prp
1/3	N	n	137	140	145	150	148	
1/4	n	n	145	152	150	155	160	
1/5		n	150	157	153	162	160	end prp
1/6		n	154	155	148	160	161	
1/7	n	n	155	153	148	161	159	
1/8		n	157	150	150	157	157	

1/17	n	n	155	148	143	150	146	
1/30	n	n	144	143	133	140	140	
2/1	n	y	143	145	135	141	143	light showers
2/6	n	n	146	140	134	136	138	
2/15	n	n	140	136	137	134		
2/22	n	n	120	122	120	125		
3/5	n	n	110	115	110	120		

West Marin Compost Record

Batch #: 13
Date of assembly: 12/20/11
Initial Quantity (cY): 152
Initial comments:

mixture- 5 manure, 2 equestrian, 1/2 sand with almond shells

Date	H20 (y/n)	Tu rn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
12/22	n	n	101	95	100			
12/23	n	n	105	99	103			
12/26	n	n	125	135	123			
12/27	n	n	127	125	122			
12/28	n	n	122	128	125			
12/29	n	n	123	126	120			
12/30	n	n	126	127	125			water draining out bottom
12/31	n	n	123	125	128			

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West Marln Compost Record

Batch #: 14
Date of assembly: 12/22/11
Initial Quantity (cY): 152
Initial comments:

mixture- 5 manure, 2 equestrian, 1/2 sand with almond shells

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp. 2	Temp 3	Temp 4	Temp 5	Comments
12/27	n	n	132	117	90			
12/28	n	n	128	118	100			
12/29	n	n	135	120	94			
12/30	n	n	130	116	99			
12/31	n	n	128	118	110			
1/2	n	n	130	120	115			
1/3	n	n	132	122	117			
1/4	n	n	132	120	110			water draining out the bottom of pile

1/5	n	n	138	125	126	
1/6	n	rl	137	132	124	
117	n	n	136	133	122	
118	n	n	135	131	131	begin prp
1/9	n	n	134	132	136	
1/10	n	rl	145	135	134	
1/11	n	Y	143	137	135	
1/12	n	n	137	140	134	
1/13	n	n	139	135	135	
1/14	n	Y	142	138	136	
1/15	n	n	148	140	137	
1/16	n	n	151	142	140	
1/17	n	Y	150	148	153	
1/18	n	n	158	145	138	
1119	n	n	155	140	140	rain
1/20	n	Y	155	145	143	rain
1/21	n	n	150	143	145	rain
1/22	n	n	153	142	143	
1/23	n	Y	150	140	142	

West Marin Compost Record,

Batch #: 15
Date of assembly: 1/10/2012
Initial Quantity (CY): 196

Initia comments:
mixture- 2 green waste, 1 sand with almond shells, 2 equestrian, and 4 cow manure

Date	H20 (y/n)	Turn I (y/n)	Temp I 1	Temp	Temp	Temp I T~mP2 3	4	Comments
1/11/2012	N	N	100	99	90	95	78	
1/12/2012	N	N	102	100	102	70	70	
1/13/2012	N	N	100	110	125	86	73	
1/14/2012	N	N	104	113	125	90	75	
1/15/2012,	N	N	112	120	140	89	80	
1/16/2012	N	N	118	125	145	91	83	
1/17/2012	N	N	131	134	143	145	90	
1/18/2012	N	N	140	150	130	135	117	
1/19/2012	N	N	143	145	143	140	118	Rain
1/20/2012	N	N	145	143	150	143	120	Rain
1/21/2012	N	N	146	145	152	144	122	Rain
1/22/2012	N	N	145	147	153	145	124	
1/23/2012	N	N	146	148	150	148	128	
1/24/2012	N	N	146	150	150	150	136	Beginprp0ac)
1/25/2012	N	N	138	145	142	140	135	
1/26/2012	N	N	136	140	147	143	135	
1/27/2012	N	Y	140	145	140	145	137	
1/28/2012	N	N	138	140	136	139	135	
1/29/2012	N	N	140	145	137	140	135	
t/30/2012	N	Y	143	148	139	145	134	
1/31/2012	N	N	140	137	139	149	150	
2/1/2012	N	N	143	148	145	150	140	Lightshowers
2/2/2012	N	Y	150	150	148	151	140	
2/3/2012	N	N	143	145	14~	140	146	
2/4/2012	N	N	145	146	145	143	150	
2/6/2012	N	Y	152	150	148	145	150	No workon2/5
2/7/2012	N	N	150	151	153	148	152~	Lightra~n
2/8/2012,	N	N	152	153	152	146	145	
2/9/2012	N	Y	!54	153	150	146	137	
2/10/2012	N	N	157	155	156	150	142	Lightshowe~
2/11/2012	N	N	156	155	158	155	150	
2/12/2012	N	N	155	156	160	154	152	
2/13/2012	N	N	158	159	157	157	157	
2/14/2012	N	N	160	162	161	159	162	

2/15/2012 N	N	145	147	143	140	142 End prp
2/22/2012 N	N	131	134	125	132	125
3/5/2012 N	N	1!8	125	120	117	125

West Marin Compost Record

Batch #: 16
Date of assembly: 1/18/12
Initial Quantity (CY):
Initial comments: mixture 2 green waste, 2 manure, 2 equestrian, and 1/2 sand with almond shells

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
1/24/2012	N	N	147	140	133	143	145	Begin prp
1/25/2012	N	N	132	135	134	137	136	
1/26/2012	1",4	N	134	132	133	135	137	
1/27/2012	N	Y	135	134	135	142	138	1st turn
1/28/2012	N	N	134	135	136	138	140	
1/29/2012	N	N	134	136	135	138	134	
1/30i2012	N	Y	135	134	135	137	135	2nd turn
1/31/2012 ~	N	N	134	135	133	135	136	
2/1/2012	N	N	140	138	135	140	140	Light showers
2/2/2012	N	Y	142	140	138	143	141	3rd turn
2/312012	N	N	136	137	135	136	143	
2/4/2012	N	N	140	142	138	140	145	
2/6/2012	N	Y	155	145	140	143	147	No work on 2/5; 4th turn
2/7/2012	N	N	153	147	144	145’	150	Light rain
2/8/2012	N	N	136	145	136	142	145	
2/9/2012	N	Y	138	135	137	140	143	5th turn
2/10/2012	N	N	140	138	142	142	145	Light showers

2/11/2012 N	N	143	140	145	148	147
2/12/2012 N	N	145	142	147	150	t49
2/13/2012 N	N	148	146	145	153	152
2/14/2012 N	N	152	153	149	156	155
2/15/2012 N	N	152	149	140	137	136
2/22/2012 N	N	131	130	120	120	125
3/5/2012 IX	N	115	119	110	115	118

West Marin Compost Record

Batch #: 17
Date of assembly: 1/27/12
Initial Quantity (cY): 66cy
Initial comments: "

Mixture- 2 green waste, 2 manure, 2 equestrian, and 1/2 of sand with ahnond shells

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
1/30	n	n	115	lOO	100"			
1/31	n	in	122	103	lOO			
2/1	in		128	120	118			light showers
2/2	n	n	150	145	132			begin prp
2/3	n	n	145	146	135			
2/4	n	n	148	149	138			
2/6		Y	148	138	135			no work on 2/5
2/7	n	n	150	142	140			light rain

2/8	n	n	154	160	168	
2/9	n	y	156	166	167	
2/10	n	n	158	168	165	light showers
2/11	n	n	157	167	166	
2/12	n	y	158	165	166	
2/13	n	n	158	161	160	
2/14	n	n	160	163	162	
2/15	n	Y	138.	156	146	
2/16	n	n	1 40	137	140	
2/17	n	n	157	150	147	
2/18	rl	y	155	151	148	
2/19	n	n	135	139	135	
2/20	n	n	135	135	135	
2/21		n	134	135	138	
2/22	n	n	135	134	136	
2/23	n	n	137	140	138	end prp
3/5	n	n	125	128	120	combined to batch 18, check batch 18 for temps

West Marin Compost Record

Batch #: 18
Date of assembly: 2/3/2012
Initial Quantity (cY): 154 yds
Initial comments:

mixture- 2 green ~vaste, 2 manure, 2 equestrian, 1/2 sand with ahnond shells

2/

Date	H20 (y/n)	Turn (y/n)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
2/6	n	n	135	145	138	132	134	begin prp
2/7	n		140	148	142	136	139	light rain
2/8		13	145	152	150	146	145	
2/9		Y	158	157	155	155	157	
2/10	n	n	156	154	150	!52	156	light showers
2/11		n	158	157	154	157	160	
2/12	n	y	160	157	155	158	161	
2/13	n	n	162	159	157	160	163	

2/14		n	162	160	159	162	163	
2/15		Y	148	155	149	160	157	
2/16	n	n	155	153	145	155	148	
2/17	n	n	160	163	150	147	140	
2/18	n	y	160	160	148	146	141	
2/19	n	n	145	140	138	135	137	
2/20	n	n	146	138	139	137	141	
2/21	n	y	142	140	140	140	145	
2/22	n	n	143	137		140	138	
2123	n	n	142	140	135	145	137	
2/24	n	n	138	136	135	143	139	
2/25		n	139	138	135	142	143	
2/26	n	n	140	141	137	141	145	end of prp
3/5	n	n	133	136	135	138	133	combined batch 17 to 18

West Marin Compost Record

Batch #: 19
Date of assembly: 2/16/12
Initial Quantity (CY): 116cy
Initial comments:

mixture- 2 green waste, 2 equestrian, 2 manure 1/2 sand with ahnond shells

Date	H20 (y/n)	Turn (yln)	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Comments
2117	n	n	117	9O	85			
2/18	n		120	105	92			
2/19	n	n	125	118	lOO			
2/20	n	n	127	128	123			
2/21	n		131	135	136			Begin prp
2/22	n	n	133	138	135			
2/23	n	n	135	140	138			
2/24	n	y	137	142	137			

2/25	n	n	135	138	134	
2/26	n	n	136	138	:137	
2/27	n	y	138	142	138	
2/28	n	n	136	;137	135	rain
2/29	n	n	138	142	137	light showers
3/1	n	r~	140	143	139	rain
3/2	n	y	137	139	135	
3/3	n	n	141	143	137	
3/5	n	y	138	140	138	
3/6	n	n	140	135	138	
3/7	n	n	142	137	141	
3/8	n	y	145	142	141	
3/9	n	~n	142	144	140	
3/10	n	n	136	141	142	
3/11	~n	n	140	138	138	di,dnt work sunday
3/12	n		138	136	140	end prp
3/13		n	140	138	145	rain

West Marin Compost Record

Batch #: 20
Bate of assembly: 2/23/2012
Initial Quantity (cY): 168cy
Initial comments:

mixture- 2 equestrian, 2 green waste, 1 manure

Date	H20 (y/n)	Turn (y/n)	Temp	Temp 2	Temp 3	Temp 4	Temp 5	Comments
2/24	n	n	142	135	148	145		Begin prp
2/25	n	n	14~i	140	152	148		
2/26	n	~n	147	142	148	143		
2/27	n	Y	148	146	140	140		
i2/28	n	n	137	147	145	147		rain
2/29	n	n	139	145	146	147		light showers
3/1	n	y	140	148	143	149		rain
3/2	In	n	137	140	139	142		

3/3	n	n	139	141	143	145	
3/5	n	y	134	138	135	138	
3/6	n		136	140	142	147	
3/7	n	n	136	136	140	145	
3/8	n	Y	135	138	137	140	
3/9	n	n	136	140	142	152	
3/10	n	n	134	138	140	142	
3/11	n	n	136	141	14t	136	didnt work on sunday
3/12	n	y	138	140	142	135	
3/13	n	n	135	138	140	136	rain
3/14	n	n	133	137	135	136	rain
3/15	n	n	134	135	133	137	light showers
3/16	n	n	135	133	135	134	rain; end prp

Appendix C

Research: Effects of Organic Matter Amendments on Net Primary Productivity and Greenhouse Gas *Emissions* in Annual *Grasslands as* printed in Ecological Society of America

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Running head:

Grassland soil amendments and carbon storage

Title: ....

Effects of organic matter amendments on net primary productivity and greenhouse gas emissions in annual grasslands

Authors:

Rebecca Ryals[1,*] and Whendee L. Silver[1]

1. University of California, Berkeley. Department of Environmental Science, Policy, and Management, 130 Mulford Hall #3114 Berkeley, CA 94720

* Corresponding author:

University of California, Berkeley. Department of Environmental Science, Policy, and Management, 130 Mulford Hall #3114 Berkeley, CA 94720

Telephone: 1-510-369-3963

E-mail: bryals@berkeley.edu

Abstract

Most of the world's grasslands are managed for livestock production. A critical component of the long-term sustainability and profitability ofrangelands (e.g. grazed grassland ecosystems) is the maintenance of plant production. Amending grassland soils with organic waste has been proposed as a means to increase net primary productivity (NPP) and ecosystem carbon (C) storage, while mitigating greenhouse gas emissions from waste management. Few studies have evaluated the effects of amendments on the C balance and greenhouse gas dynamics of grasslands. We used field manipulations replicated within and across two rangelands (a valley grassland and a coastal grassland) to determine the effects of a single application of composted green waste amendments on NPP and greenhouse gas emissions over three years. Amendments elevated total soil respiration by 18 4- 4 % at both sites, but had no effect on nitrous oxide or methane emissions. Carbon losses were significantly offset by greater and sustained plant production. Amendments stimulated both above- and belowground NPP by 2.1 4- 0.8 to 4.7 4- 0.7 Mg C ha^{-1} over the three-year study period. Net ecosystem C storage increased by 25 to 70 % without including the direct addition of compost C. The estimated magnitude of net ecosystem C storage was sensitive to estimates ofheterotrophic soil respiration, but was gr~eater than controls in five out of six fields that received amendments. The sixth plot was the only one that exhibited lower soil moisture than the control, suggesting an important role of water limitation in these seasonally dry ecosystems. Treatment effects persisted over the course of the study, which were likely derived from increased water holding capacity in most plots, and slow-release fertilization from compost decomposition. We conclude that a single application of composted organic matter can significantly increase grassland C storage and that effects of a single application are likely to carry over in time.

Keywords

net primary productivity, soil respiration, Mediterranean climate, annual grassland ecosystems, methane, nitrous oxide

Introduction

Rangelands represent the largest land-use area globally~ covering more than one-quarter of the world's land surface and storing approximately one-third of the world's terrestrial C in soils and vegetation (White et al. 2000, Asner et al. 2004). The primary economic output of rangelands is livestock production, supplying meat, dairy products, leather, and wool (Herrero et al. 2009). The sustainability and profitability of rangelands is largely a function of forage quality and quantity (Briske et al. 2011). However, these ecosystems have, to varying degrees, experienced degradation of vegetation and soils due to overgrazing, plant invasions, and climate change (Asner et al. 2004, Schipper et al. 2007, Bai et al. 2008). Thus, management practices aimed at enhancing plant production may have considerable potential to restore or increase grassland C storage and feed back on the global C cycle (Schimel et al. 1990, Conant et al. 2001, Follett et al. 2001, Schuman et al. 2002, Derner et al. 2007).

Management practices can affect grassland C storage or loss by altering soil chemical or physical characteristics (Cambardella and Elliott 1992, Paustian et al. 1997, Janzen et al. 1998), plant morphology or growth, soil moisture, or rates of microbial activity (Str0mberg and Griffin 1996, Steenwerth et al. 2002, Jones and Dom~elly 2004). Amending soils with organic material generally increases nutrient availability, and thus is a common practice used in cropping systems to enhance NPP (Cassman et al. 2002, Blair et al. 2006) and in some land reclamation sites to facilitate soil amelioration and plant establishment (Lamey and Angers 2012). Animal manure, crop residues, composted urban waste, and sewage sludge are common forms of orgamc matter amendment.

The application of organic matter to rangelands has been proposed as an approach for increasing plant productivity, as a waste management strategy, and for climate change mitigation (Cabrera et al. 2009, Hall and Sullivan 2001). Organic matter additions to rangeland soils increase soil C pools directly and have the potential to indirectly increase ecosystem C storage by stimulating plant growth. Organic matter additions to rangelands can also provide a pathway to divert organic waste from landfills or for manure management from nearby dairies, thereby reducing greenhouse gas emissions from traditional waste management.

Carbon benefits of enhanced NPP due to organic matter amendments may be offset from a global warming perspective by the stimulation of soil greenhouse gas emissions. Organic matter amendments increase soil C and nitrogen (N) pools and may alter soil environmental conditions (e.g., moisture, temperature, and pH), thereby increasing the potential for carbon dioxide (CO2), nitrous oxide (N20), and methane (CH4) emissions (Gregorich et al. 2005). The extent of management effects on soil greenhouse gas emissions is a large source of uncertainty in grasslands (Soussana et al. 2004). Manure amendment can increase CO2 and N20 fluxes (Chadwick et al. 2000, Dalal et al. 2003, Mosier et al. 2004, Davidson et al. 2009); composted animal waste and plant matter tends to result in lower greenhouse gas emissions relative to green manures or synthetic fertilizers (Vallejo et al. 2006, Alluvione et al. 2010). However, the effects of organic matter additions on greenhouse gas dynamics in rangelands are largely unstudied (Lynch et al. 2005, Cabrera et al. 2009).

The purpose of this study was to examine the immediate and residual effects of amendments of composted green waste on plant production and greenhouse gas emissions in annual grasslands. We hypothesized that the application of composted organic matter to rangeland soils would increase the above- and belowground net primary productivity (NPP) for at least one year and that these increases in ecosystem C inputs would be partially or wholly offset by elevated rates of soil greenhouse gas emissions (CO2, N20, and CH4). We tested this hypothesis over three years using replicated field experiments in the two dominant annual grassland types in California. Unlike perennial grassland systems, mmual grasses germinate, grow and die over an mmual cycle allowing us to estimate net ecosystem C storage from the changes in plant and soil C pools and fluxes.

Materials and Methods

Study sites

Rangelands are the dominant cover type in California covering an estimated 17-23 million ha (FRAP 2003, Brown et al. 2004). Of this area, approximately 9 million ha are valley or coast range, grasslands (Kuchler 1964). Valley grasslands extend along the central and southern parts of California and are comprised largely of non-native annual grass and forb species such as *Avena barbata*, *Bromus hordeaceus, Lolium multiflorum, Erodium* spp., and *Trifolium* spp. (Bartolome et al. 2007), as well as invasive species such as *Taeniatherum caput-medusae.* Coast range (hereafter coastal) grasslands experience a mesic coastal climate and are also dominated by a similar mix of non-native annual grasses. Native perennial grass species, such as *Danthonia californica* and *Stipa pulcra* can also occur (Jackson and Bartolome 2002). The Mediterranean climate of both valley and coastal grasslands of California is characterized by cool, wet winters and warm, dry summers. The growing season begins with the rains in September-November and ends with the onset of the dry season in April-June.

The field experiment was conducted on valley grasslands at the Sierra Foothill Research and Extension Center in Browns Valley, CA (39.24 °N, 121.30 °W) and on coastal grasslands in Nicasio, CA (38.06 °N, 122.71 °W). Annual precipitation averages 730 mm y-1 (22 y mean) at the valley grassland and 950 mm y-1 at the coastal grassland. During the years of this experiment, the valley grasslands received 380, 641, and 843 mm/y of precipitation, primarily as rainfall; mean air temperatures ranged from 2 °C in January to 35 °C in July. Soils are derived from Mesozoic and Franciscan volcanic rock and classified as xeric inceptisols and alfisols in the Auburn-Sobrante complex (Beaudette and O'Geen 2009, http://casoilresource/lawr.ucdavis.edu/soilsurvey). The site has been grazed by cattle for at least 150 years (D. Flavell, pers. comm.). At the coastal grassland, annual precipitation during the study period was 771, 1050, and 1163 mrrdy, and mean air temperatures ranged from 6 °C in January to 20 °C in July. Soils are derived from Franciscan m~lange and classified.as mollisols in the Tocaloma-Saurin-Bonnydoon series (Beaudette and O'Geen 2009, http://casoilresource/lawr.ucdavis.edu!soilsurvey). The site has been grazed by cattle since at least 1900, with a brief period of exclusion from 2000-2005.

Experimental Design

The field experiment was established in October 2008 and continued for three growing seasons to August 2011. Treatments consisted of untreated controls and composted organic matter amendments. Plots were 25 m by 60 m buffered by a $\geq$ 5 m strip arranged in three randomized complete blocks. Blocks were situated in different microwatersheds in each grassland type to capture some of the landscape-scale heterogeneity associated with vegetation communities, potential residual effects of field-scale land use history, and soil texture. An organic-rich soil amendment was produced by adding a single application of commercially available composted organic green waste (Feather River Organics, Marysville, CA) with a N concentration of 1.87 % and a C:N ratio of 11. A thin surface dressing approximately 1.3 cm thick (equivalent to 1.42 kg C/m^2 and 129 g total N/m^2, or 7.0 kg dry matter m^{-2}) was applied in December 2008. All plots were grazed using a rotational regime typical of the region to achieve a residual dry matter level of approximately 130 g/m^2. Sites were grazed during the spring and fall for up to four weeks, depending on the amount of available forage. During grazing, cattle were not isolated within plots, but instead allowed to graze the entire block.

Climate Data, Soil Moisture, and Soil Temper.ature

Local daily rainfall and air temperature records were obtained from Browns Valley for the valley grassland site (http://wwwcimis.water.ca.gov/cimis/data.jsp) and from the Marin Municipal Water District (J. Klein, pers. comm.) for the coastal grassland site. We define a water year as the period that encapsulates one rainy and one dry season, spanning from September 1 through August 31 of the following year (Chou et al. 2008).

In May 2009, automated TDR-based probes were installed at 0 to 30 cm depth to measure volumetric water content (Campbell Scientific CS616, n = 3 per plot). Automated soil temperature probes were installed at 0 to 5 cm depth (Campbell Scientific 108L, n = 1 per plot). Soil moisture and temperature data output was averaged on hourly and daily timescales.

Soil Greenhouse Gas Emissions

Soil respiration was measured weekly during the growing season and every other week during the summer over the first two water years. Soil C02 fluxes are extremely low with little temporal variability during the summer in annual grasslands (Nijs et al. 2000, Xu and Baldocchi 2004, Chou et al. 2008). We measured soil respiration monthly during the third water year. Soil CO_2 fluxes were measured during daylight hours using a LI-8100 infrared gas analyzer (approx. 2.5 min flux periods, Li-Cor Biosciences, Lincoln, NE) fitted with an opaque soil efflux chamber. The chamber was used in a survey mode with polyvinyl chloride collars (n - 5 per plot). Collars were driven approximately 3 cm into the soil and left to equilibrate for at least 30 minutes before flux measurements were taken. Soil respiration measurements were started three (coastal) to six (valley) weeks prior to organic matter applications. As a first approximation of annual soil respiration rates we used linear interpolation between sampling time points and summed the resulting data as an estimate the mass of C per unit area respired over the water year (Silver et al. 2005, Chou et al. 2008). Previous work at the valley grassland identified the importance of the fall wet-up event for estimating accurate annual soil respiration fluxes (Chou et al. 2008). In attempt to capture the largest fluxes, we measured soil respiration no more than 48 hours before and after fall wet up events.

Soil CH_4 and N20 fluxes were measured bi-weekly for the first six months, which was when we expected to see the largest fluxes (Chou et al. 2008), and monthly thereafter until September 2010. Vented static flux chambers (Keller & Reiners 1994) were placed at four random locations ~vithin each plot during each sampling period. Thirty mL gas samples were collected from the chamber headspace at 0, 5, 15, 25, and 40-minute time points, immediately transferred to evacuated glass vials, and analyzed within 72 hours (Chou et al. 2008). Methane concentrations were analyzed on a gas chromatograph using a flame ionization detector, and an electron capture detector was used to analyze N20 concentrations. Fluxes were then calculated using an iterative exponential curve fitting approach (Matthias, et al. 1978).

Wet up events can stimulate trace gas emissions, particularly in dry, organic rich soils (Fierer and Schimel 2002, Chou et al. 2008). We conducted a laboratory incubation experiment to determine the potential trace gas emissions from amended and control soils during wet up events. Soils from the valley grassland were collected from control and amended plots (n - 9 per plot) and composited by treatment. Approximately 200 g of soil were placed into quart-sized mason jars and categorized as one of four incubation treatments (n = 5): control, control + wet up, amended, and amended + wet up, where control and amended treatments refer to ambient dry-season field moisture conditions (approximately 4 % gravimetric soil moisture) and wet up refers to the addition of 40 mL of deionized water representing an average first rainfall event in autumn. Jars were incubated in a dark growth chamber with daily air temperatures fluctuating from 20 to 35°C, a typical range experienced during wet up events in the field. Soil CO2, N20, and CI-I4 fluxes were measured daily until trace gas fluxes were not significantly different between treatment and controls (30 days). Cumulative fluxes were calculated as described above. Positive soil greenhouse gas fluxes indicate net source to the atmosphere, whereas negative values indicate a terrestrial sink.

Aboveground and Belowground Net Primary Productivity

The vegetation communities at the study sites are strongly dominated by annual grass and forb species. These plants germinate at the onset of the fall rains and die at the end of the wet season. Aboveground biomass at the end of the wet season plus biomass removed during earlier grazing events is equivalent to aboveground net primary production (ANPP) (Harper et al. 2005). Aboveground biomass was determined by harvesting plants in a 200 cm^2 area (n = 9 per plot) at the time of peak biomass at the end of the growing season. All aboveground vegetation was clipped to the soil surface. Harvested plant material was dried at 65 °C, weighed, and analyzed for C concentration on a Carlo Erba Elantech elemental analyzer (Lakewood, NJ). Carbon content of aboveground biomass was determined by multiplying C concentration by mass. Aboveground biomass was also measured using the above approach no more than 24 hours immediately before and after grazing to determine biomass removed by cattle (Marshall et al. 1998). Aboveground NPP was determined by adding the biomass removed by cows to the biomass collected at peak standing biomass. Plots at the coastal grassland were grazed during or jus~ before peak standing biomass due to site-specific management requirements, thus biomass measurements were made prior to grazing at this site and may slightly underestimate ANPP.

The root systems of annual grasses are concentrated in the soil surface layer, with less than 15 % of root biomass occurring below 15 cm and a majority of root growth occurring before April (Jackson et al. 1988). B elowground net primary productivity (BNPP) was determined by measuring root biomass during late spring of water years 2 and 3 and adjusting values by a multiplication factor of 1.5 to account for intra-annual root turnover (Higgins et al. 2002). Eight 0 tol0 cm and four 10 to 20 cm quantitative soil cores (6 cm diameter) were sampled per plot. Roots from each core were extracted according to Metcalfe et al. (2007) with the following modifications based on methods testing with soils from these sites. Roots from each core were picked by hand for three ten-minute intervals, sieved at 2 mm to break up large aggregates, and picked by hand for five additional ten-minute intervals for a total of 80 minutes. Roots were then rinsed free of soil and dried at 65 °C until reaching a constant dry mass. For each core, the pattern of cumulative extraction over time was used to predict total root biomass. Upon drying and weighing, roots were finely ground and analyzed for C concentration on a Carlo Erba Elantech elemental analyzer (Lakewood, NJ) using acetanilide as a standard. Carbon content of belowground biomass was detelrnined by multiplying.C concentration by mass. All production data (ANPP, BNPP, and NPP) are expressed in units of mass of C per area using the biomass to C content conversions described above. Expressing production terms using this convention allows us to explicitly compare C inputs and outputs.

Soil carbon content and bulk density

Soil bulk density (0-10 cm depth) was measured by digging pits (one per plot) and carefully excavating 9 cm diameter cores approximately 5 cm back from an undisturbed face of the pit. All bulk density measurements were rock-corrected. Upon extraction from cores, dry rock masses and volumes were measured and subtracted from initial bulk density calculations.

Total soil organic C concentrations were measured prior to the application of organic matter amendment and at the ends of each subsequent growing season (May or June). Soils were collected using a 7 cm diameter corer to 10 cm depth (n = 9 per plot). Large roots and identifiable compost fragments were removed by hand. Soils were then air-da’ied and pulverized with a ball grinder (SPEX Sample Prep Mixer Mill 8000D, Metuchen, NJ). Carbon concentrations w.ere measured using a Carlo Erba Elantech elemental analyzer (Lakewood, N J) using atropine as a standard and converted to content using bulk density values specific to each plot.

Modeling Net Change in Ecosystem Carbon Storage

We modeled the annual net change in ecosystem C storage with and without compost additions using an approach modified from Hanson et al. (2000) and Chou et al. (2008):

$$\text{Net C Storage} = ANPP + BNPP - Rh - Roa - DOC$$

where Rh is heterotrophic respiration which includes the non-root and non-rhizosphere component of soil respiration during the growing season. Roa is CO_2 evolved from decomposition of the organic matter amendment, and DOC is dissolved organic C losses.

In annual grasslands, the sum of ANPP and BNPP represents total annual litter inputs, which turnover approximately annually (Heady et al. 1992). Partitioning soil respiration into its autotrophic and heterotrophic components is difficult in annual grasslands, and outside the scope of this study. Instead, we modeled net ecosystem C storage with a range of Rh values to represent a low (30 %), medium (50 %), and high (60 %) level measured in similar ecosystems (Craineet al. 1999, Zhou et al. 2007, Chou et al. 2008). Carbon losses through Rh were constrained to the growing season, as no treatment differences in soil respiration were detected during the dry summer months. We assumed that the relative proportion of soil respiration components was equal across treatments as a first approximation. We used 0.05 yr^{-1} as the decomposition rate of the compost (Lynch et al. 2005) to calculate annual losses of compost as CO_2, which is similar to the rate derived from a DayCent model simulation (Ryals et al. in prep). We assumed that the compost mass reduction via decomposition was lost primarily as CO_2 to the atmosphere. Carbon losses through leaching of DOC are negligible in these ecosystems relative to soil CO_2 effluxes (Dahlgren and Singer 1994, Sanderman and Amundson 2009). Therefore, DOC is assumed to be zero for estimates of net C storage. In this experiment, treatment plots were amended only once, at the beginning of water year 1. Therefore, direct C inputs from compost addition are constrained to water year 1, but losses through decomposition carry over all three years. Belowground NPP was estimated for water year 1 using the plot-specific root:shoot ratios averaged for water years 2 and 3.

Statistical analys&

One way analyses of variance (ANOVA) were used to identify statistically significant treatment effects on soil organic C, cumulative soil CO_2 flux, soil moisture, soil temperature, ANPP, BNPP, and net ecosystem C storage. Analyses included a blocking effect and were performed separately for valley and coastal sites. To assess changes over time within sites, we used repeated measures multivariate analysis of variance (MANOVA) with ANPP, BNPP, soil moisture, soil temperature, and soil CO_2, N_2O, and CH_4 fluxes as response variables. Each grassland type was analyzed separately with block, treatment, time, and interactions as MANOVA model effect factors. Correlations between net C storage, ecosystem C pools, soil moisture, and precipitation were .explored using multiple linear regressions.

Statistical tests were performed using JMP 7.0.2 (SAS Institute Inc.). Variables that were not normally distributed were log transformed to meet assumptions for ANOVA. Data are reported either as mean values or treatment differences followed by ± 1 standard error. Statistical significance was determined as $p < 0.10$ unless otherwise noted.

Results

Response of Soil Respiration and Greenhouse Gas Emissions to Organic Matter Amendment

Soil respiration (root plus microbial respiration) was significantly higher in amended soils than in control soils during the growing season ($p < 0.0001$ at both sites) (Figure 1). There was approximately 18 ± 2 % and 19 ± 2 % more C respired from the amended soils relative to the controls from the valley ($p = 0.06$) and coastal ($p = 0.10$) sites cumulatively over the three years of the study (Figure 2). Within sites soil CO_2 fluxes varied by as much as 30 to 50 %

among years, reflecting patterns in the timing and amount of rainfall. Soil respiration was positively correlated to soil moisture ($R^2 = 0.51$, $p < 0.001$ at valley dud $R^2 = 0.65$, $p < 0.001$ at coastal), and treatment effects (amended-control) were positively correlated to annual precipitation (R^2 - 0.47, $p < 0.05$ for both sites). The highest cumulative soil respiration losses occurred during water year 2 which was characterized by late warm season rains, and treatment differences in cumulative soil respiration were not statistically significant during this time period.

Approximately 88 ± 0.01% and 73 ± 0.07 % of the cumulative annual soil CO_2 efflux occurred during the growing season at the valley and coastal grassland, respectively, with no statistically significant treatment effect on the seasonal distribution of soil respiration. Analysis of paired-plot treatment differences of growing season soil respiration revealed that amended soils at the valley grassland lost an additional 614 ± 191 g CO_2-C m^{-2} over the three year study. Similar trends were observed at the coastal grassland which experienced increased losses of 646 ± 162 g CO_2-C m^{-2} from the amended plots.

There were no significant treatment effects on CH_4 and N_2O fluxes, and no significant changes over time. At the valley grassland, mean CH_4 fluxes were -2.5 ± 0.6 g CH_4-C ha^{-1} day^{-1}, and mean N_2O fluxes were 0.13 ± 0.13 g N_2O-N ha^{-1} day^{-1}. At the coastal grassland, mean CH_4 fluxes were -1.4 ± 0.7 g CH_4-C ha^{-1} day^{-1}, while mean N_2O fluxes were 1.0 ± 0.4 g N_2O-N ha^{-1} day^{-1}.

Greenhouse gas emissions during wet up events

We conducted a controlled laboratory experiment to estimate the potential greenhouse gas emissions associated with wet-up events. Wet-up led to a pulse of CO_2 from both amended

and control soils, and soil respiration in amended soils remained elevated over controls for 22 days (p < 0.05). Nitrous oxide fluxes were also elevated from amended soils and lasted four days following wet up (p < 0.01; Figure 3). Methane fluxes were negligible and did not respond to the wet up event. Cumulative N20 emissions accounted for just 0.49 + 0.05 and 0.83 + 0.13 % of the total global warming potential during the wet up event from control and amended soils, respectively. The vast majority of the greenhouse gas emissions from these soils was from CO2.

Response of Net Pr~maty Productivity and Soil C to Organic Matter Amendment

Organic matter amendments significantly enhanced plant growth at both the valley and coastal grassland sites (Appendix A). During the first water year, amendments increased ANPP by 70 % at the valley site and by 44 % at the coastal site. The effects of the one-time application of organic matter carried over into the two subsequent growing seasons at a similar magnitude. Over all three study years, ANPP increased by a total of 436 4- 68 and 161 4- 78 g C m"2 (p < 0.01) at the valley and coastal grasslands, respectively (Figure 4). Average annual increases in ANPP were 145 4- 16 and 54 + 3 g C m^{-2} at the valley grassland and coastal grassland, respectively (p < 0.05 for all years at both sites). Shoot to root ratios increased significantly with organic matter applications at the valley grassland from 3.75 + 0.06 to 5.45 + 0.09 (p = 0.08) and did not change significantly at the coastal grassland, where the shoot to root ratio was 3.00 4- 0.14. Root biomass increased at both sites, particularly in the 0-10 cm depth (Figure 4). At the valley grassland, root biomass increased by 33.6 + 11.7 g C m^{-2} in amended plots at the 0 to 20 cm depth over three years (p < 0.05). Belowground NPP showed similar, but more variable trends with amendments at the coastal grassland. Organic matter amendments significantly increased total NPP by 2.0 + 0.8 Mg C ha^{t} at the coastal grassland ($p = 0.10$) and 4.7 ~- 0.7 Mg C ha^{-1} at the valley grassland ($p < 0.01$) over the three year study period (Figure 5).

By the end of the first water year, organic matter additions s~gnificantly increased the soil organic C pool by 24 % in the 0 to 10 cm depth at the valley grassland site (p - 0.06). Soil C stocks remained larger in water years 2 and 3 ($p = 0.01$) (Figure 6).

Changes to net ecosystem carbon storage

We assessed the net impact of organic matter amendments at the field scale through a mass balance of inputs and outputs. When including C added in compost, the amended plots showed an increase in net ecosystem C storage of 17.7 4. 1.4 and 13.8 ~- 1.8 Mg C ha^{1} ($p < 0.0001$) at the valley and coastal g~assland, respectively. A large portion (65 to 88 %) of the additional ecosystem C was due to the direct addition of C from the compost amendment in water year 1, only 12 % of which decomposed during the three year study period.

Organic matter additions also altered ecosystem C fluxes. Above- and belowground NPP increased, as did C emissions via soil respiration. Modeled C storage from both control and amended plots was consistently negative across years and sites (Appendix A1), indicating that these annual grasslands were losing C, findings that have been observed in many grassland ecosystems (Ojima et al. 1994, Bellamy et al. 2005, and Chou et al. 2008). The net balance of C fluxes (excluding compost amendments) was consistently more positive for all amended plots compared to control plots at the valley grassland site and at two out of three paired plots at the coastal grassland (Figure 7). The magnitude of the response was sensitive to assumptions about the contribution of heterotrophic respiration to total soil respiration. Assuming 50 % Rh, valley grasslands gained 198 4- 50 to 582 4- 43 g C/m^{2} over three years following a single application of compost. Amended fields from two sets of paired plots at the coastal grassland showed similar gains of 192 4- 75 and 241 4- 96 g C/m^2. The third showed a decline in C storage by 281 4- 60 g C/m^2. For this pair of plots, soil volumetric water content was lower in the treatment than in the control, whereas the opposite trend was observed for all other fields (Figure 1).

Discussion

Patterns in soil respiration and greenhouse gas emissions

Organic matter amendments to surface soils increased soil respiration by an average of 18 to 19 % over the three-year study. Soil respiration is the combination ofheterotrophic and autotrophic respiration, and both could have been stimulated by compost additions. Adding composted organic material to the soil surface likely increased the decomposition rate of the compost, although compost, having already experienced intensive decomposition during formation, is generally considered more stable material than fresh litter (Bernal et al. 1998, Goyal et al. 2005). Approximately 12 % of the added compost decomposed over the three-year study; this resulted in the emission of 171 g CO2-C/m^2, or approximately 3.5 4- 0.2 % of the total C respired from amended soils over the study. Compost decomposition contributed 24 + 6 % of the treatment differences in soil respiration. If we assume that autotrophic respiration accounted for 50 % of the total soil respiration measured in both treatment and controls (Hanson et al. 2000), then the remaining heterotrophic respiration (not derived directly from compost) was only approximately 6 ± 3 % greater in the amended treatment than in the control. This indicates that a priming effect by the compost on background soil C losses, if it occurred, was small (Kuzyakov et al. 2000, Kuzyakov 2010). It is important to note that soil respiration rates are temporally dynamic and respond rapidly to changes in soil moisture and temperature. Interpolation of measurements in time may miss important CO_2 fluxes.

Organic matter amendments could have altered the ratio of autotrophic to heterotrophic respiration in these soils. We provide evidence here that both autotrophic and heterotrophic respiration were likely to have increased as a result of the amendments. The tight coupling of root and microbial respiration in annual grassland soils may limit the degree to which their ratio can change. For example, the morphology and phenology of annual grasses results in little carbohydrate storage relative to perennial plants, thus root respiration is likely to be directly proportional to plant activity at short temporal scales (Warembourg and Estelrich 2001, Tang and Baldocchi 2005). Plant activity increased as a result of compost additions, which likely increased autotrophic respiration. Similarly, the majority of heterotrophic respiration in soils comes from recently derived organic matter (Trumbore 2000; Giardina and Ryan 2002, Carbone and Trumbore 2007). During the growing season, most of this input occurs belowground in annual grasslands (Higgins et al. 2002). Therefore, rates of heterotrophic respiration were likely to have increased as a result of increased plant activiU (i.e. the production of labile organic matter), and are likely to be relatively tightly coupled with NPP in annual grassland soils.

We predicted that compost additions would increase the production and emissions of N_2O and CH_4 from rangeland soils. Grasslands can be an important source of N_2O (Bouwman et al. 1993), and manure application to rangeland soils can significant increase N_2O emissions (Rees et al. 2004, Jones et al. 2007). Organic matter amendments increase both the amount of mineral N in soils and water holding capacity of soils, creating conditions favorable for N_2O production via nitrification and denitrification (Firestone and Davidson 1989). Similarly, we expected that organic matter amendments would increase CH_4 emissions or decrease the net rate of CH_4 uptake by soils (Le Mer and Roger 2001, Moiser et al. 2004). Although soil moisture was higher in amended fields, we saw no significant changes in N20 or CH4 fluxes in these soils. The lack of significant N20 emissions with compost additions could be due to the relatively slow decomposition of the organic matter, slow rate of N release from decomposition, and greater plant N uptake as evident by increased biomass production. We expected the highest rates of N20 emissions to occur during wet up events when temperatures were relatively high and plant-microbe competition for mineral N was low (Birch 1958, Franzluebbers et al. 2000, Grover et al. 2012). In our laboratory incubation, we were able to stimulate N20 production for a short time period following soil wetting, but rates of N20 emissions as a global warming potential were insignificant, particularly relative to the high CO~ emissions observed from both treatment and control soils. In contrast, soil N20 emissions from temperate grasslands amended with a range of chemical fertilizers and manures were up to 4900 g N20-N ha^{-1} day^{-1} compared with pre-amendment emissions of 4 g N20-N $ha^{-\sim}$ day^{-1} (Rees et al. 2004, Jones et al. 2007).

Effects on above- and belowground net primary production and soil carbon

We observed large increases in ANPP in both grassland types, and consistent trends over time despite a wide range in precipitation among water years. In annual grasslands, ANPP typically increases linearly with increasing precipitation (McCulley et al. 2005, Chou et al. 2008, Wu et al. 2011). We did not observe a significant linear increase in ANPP with rainfall during the study period. Aboveground NPP was greater in amended plots than in controls, findings that are consistent with studies measuring the response of crops to amendments (Edmeades et al. 2003, Badgley et al. 2007) as well as stx~dies of grassland response to N fertilization (Baer et al. 2003, LeBauer and Treseder 2008, Yahdjian et al. 2011). Aboveground NPP at the valley grassland showed a much stronger response than the coastal grassland, even when considering the slight differences in sampling times. Aboveground NPP at the valley site increased by 78 4- 13 % in the amended plots over the 3 years relative to 42 + 14 % at the coastal site. This could be due to a greater impact of compost amendments on water and N availability at the former site compared to the more mesic coastal grassland (Harpole et al. 2007).

.In rangelands, ANPP provides forage for livestock (Asner et al. 2004, Briske et al. 2011). Land management decisions in rangelands often focus on increasing the amount, quality, and sustainability of forage production. These decisions in turn affect the feasibility and sustainability of associated C sequestration or greenhouse gas offset programs. In annual grasslands, ANPP can often be predicted by the timing and magnitude of rainfall and the previous year's production (Hedrick 1948, Heady 1956, Bartolome et al., 1980, Chou et al., 2008). Organic matter additions and other management practices that increase the size of soil C pools are likely to have a positive impact on NPP through increased water holding capacity and N availability. Compared to chemical fertilizers, which provide a short-term pulse of nutrients (Wight and Godfrey 1985, Fauci and Dick 1994), organic matter amendments act as a slow-release fertilizer during decomposition (Sommers 1977), and thus may provide longer-term or sustained increases in aboveground NPP (e.g. Gerzabek et al. 1997, Blair et al. 2006). These effects may last several years. The long-lasting effects of a single application of compost could serve to buffer impacts of decreasing precipitation predicted for some regions with climate change (Stavast et al. 2005, Kowaljow et al. 2010).

Detecting changes in C storage in the bulk soil pool (i.e. without fractionation or other separation techniques) is difficult due to the large variability of the soil C pool in grasslands. In this study, recognizable compost fragments were removed prior to soil C determination to avoid overestimating C pools from amended soils. Regardless, we were able to detect an increase in the bulk soil C pool at the valley site..The increase in soil C was likely derived from a combination of compost incorporation into soil and additions of newly fixed C from NPP. In a tlu'ee year study monitoring the effects of a one-time application of either inorganic or organic fertilizers in a degraded semiarid rangeland in Patagonia, Kowaljow et al. (2010) observed a similar pattern of increase in soil organic C and enhanced microbial activity. Soil organic C formation and stabilization is promoted by management practices or technologies that increase the quantity of C inputs (Gentile et al. 2011). In rangelands, soil organic content is strongly dependent on root biomass and turnover due to the high belowground allocation of grasses and forbs and longer residence time of root-derived C (Jobbagy and Jackson 2000, Kgtterer et al. 2011). In our experiment, root biomass increased significantly in the valley grassland and followed the same trend in the coastal grassland. Application of composted organic material to the soil surface increased both above- and belowground productivity over the three growing seasons, leading to greater annual C inputs from vegetation. Thus, management techniques like composted organic matter additions that increase production have the potential to increase the size of the soil organic C pool over the long-term.

Changes in net ecosystem carbon storage

The control plots from both sites appeared to be losing C. The ecosystem C balance of grasslands is typically highly variable over time and space (Xu and Baldocchi 2004, Novick et al. 2008, Klumpp et al. 2011), but several recent studies have reported C losses from rangeland soils (Bellamy et al. 2005, Schipper et al. 2007, Chou et al. 2008). Chou et al. (2008) reported significant losses of soil organic C for four consecutive years in a Mediterranean annual grassland with and without experimental rainfall additions. The greatest losses occurred in a year with late-season (late spring-summer) rainfall. In annual grasslands, late, warm-season rainfall can stimulate heterotrophic respiration after plants have stopped growing or have senesced, resulting in ecosystem C losses. Carbon storage in grasslands is also sensitive to shifts in vegetation. Continual declines in ecosystem C storage may also be explahled by a non-equilibrium stares of California grasslands and ongoing gradual declines in soil C following almual grass invasion (Koteen et al. 2011).

Organic matter amendments decreased the rate of C loss in most plots. This was true even when not considering the C added via the amendments, and was due to the stimulation of NPP. Assuming that heterotrophic respiration was 50 % of total soil respiration (see Figure 8 for a range ofRh" Ra scenarios), rates of net ecosystem C storage increased by 25 to 70 % with organic matter amendments with a rate of C sequestration of 51 4- 77 to 333 4- 52 g C/m^2 over the three year study. This value increases to 1,770 4- 142 to 1,383 ± 188 g C/m^2 when considering the amendment C added at the field scale. A full life cycle assessment would be needed to determine the actual greenhouse costs or savings beyond the field scale, but if organic matter amendments are diverted from fates with high greenhouse gas emissions (i.e. landfills, manure slurry ponds) then considerable C offsets may be achieved through this management approach (DeLonge et al. submitted).

Our results show that a single application of composted organic matter led to sustained increases in NPP for at least three years, with no sign of diminishing effects. Moreover, increases in plant production significantly offset elevated soil respiration from microbial activity in five out of six paired plots. The amended plot that had lower net C storage relative to its paired control plot also had lower soil volumetric water content, whereas the opposite trend was observed at the other fields (Figure 2). This finding suggests that water limitation has the potential to alter the source-sink potential of annual grasslands (Harpole et al. 2007).

Conclusions

We found that a single application of composted organic matter shifted the C balance of annual grassland ecosystems and resulted in greater C storage. Increases in above- and belowground NPP were observed over three water years, with no obvious sign of a diminishing trend. Enhanced plant productivity was partially offset by elevated soil respiration, but we detected no statistically significant treatment effects on N20 or CH4 fluxes. We were able to detect an increase in soil C at the valley site, which was surprising given the large background pool size.

Our results have important implications for rangeland management in the context of climate change mitigation. Urban and agricultural green waste is often an important source of greenhouse gas emissions (IPCC 2001). Here we show that an alternative fate for that material can significantly increase NPP and slow rates of ecosystem C losses at the field scale. This approach provides important co-benefits to land owners, such as the sustained increase in forage production measured here. Multi-year field studies are critically needed to explore the potential of ecosystem management to contribute to climate change mitigation. These data are also needed to construct comprehensive and credible life-cycle analyses that explicitly include ecosystem dynamics in C offset protocols.

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Appendix A. Carbon pools and fluxes from control and organic matter amended plots for three water years at the valley and coastal grassland experimental sites.

Figure 1. Daily precipitation data from September 2008 to August 2011 measured at (a) the valley grassland and at (b) the coastal grassland. Air temperature data from (c) va!ley and (d) coastal grasslands. (e) Paired-plot treatment difference of volumetric soil water content (0 to 30 cm) at the valley grassland. Values above zero indicate greater soil moisture content in amended soils compared to control soils. Black line is mean of all three blocks and gray area is =k 1 standard error. (f) Paired-plot treatment difference in volumetric soil water content (0 to 30 cm) at the coastal grassland. Black line is mean of all two blocks and gray area is 4- 1 standard error. Dark gray line is mean of coastal grassland block 2, indicating greater soil water content in the control plot. Paired-plot treatment difference in soil respiration at (g)valley and (h) coastal grasslands. Error bars are ~- 1 standard error, Gray block indicates measurements taken prior to amendment. Values above zero indicate greater total soil respiration from amended soils compared to control soils. There were no treatment differences in soil temperature at either grassland ($p > 0.10$).

Figure 2. Ammal total soil respiration for three water years (WY) from the valley and coastal grassland experimental field sites. Bars are means of paired-plot treatment differences with + 1 standard error bars. Instantaneous fluxes (measured approximately weekly) were linearly intel~olated and integrated to obtain mass of C per unit area per year. Values above zero indicate greater total soil respiration from amended soils compared to control soils. * indicates $p < 0.05$.

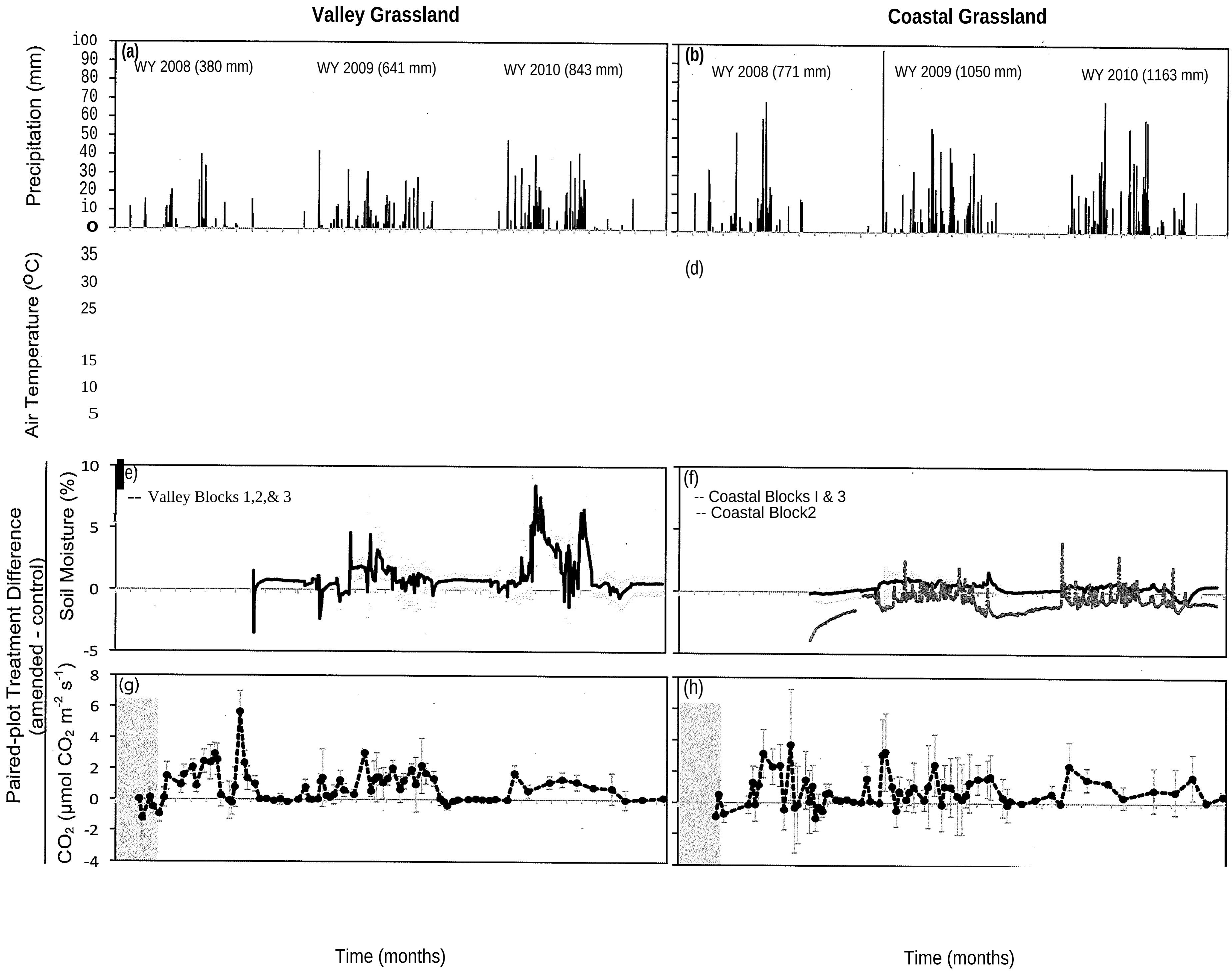
Figure 3. Greenhouse gas emissions during a 30-day laboratory incubation of valley grassland control and amended soils. Soils were incubated in quart-sized mason jars (approximately 200 g) in a growth chamber under.typical late summer climate. A fall wet up event was simulated by the addition of 40 mL of distilled water. (a-b) Fluxes of CO2 and N20 were significantly great from amended soils compared to control soils for 22 ($p = 0.018$) and 4 (p - 0.009) days, respectively. Methane fluxes were not significant from zero from both treatments. Symbols are means ± 1 standard error ($n = 5$). (c) Cumulative N20 emissions accounted for 0.5 % of total emissions from control soils and 0.8% of total soil greenhouse gas emissions evolved during the 30-day experiment.

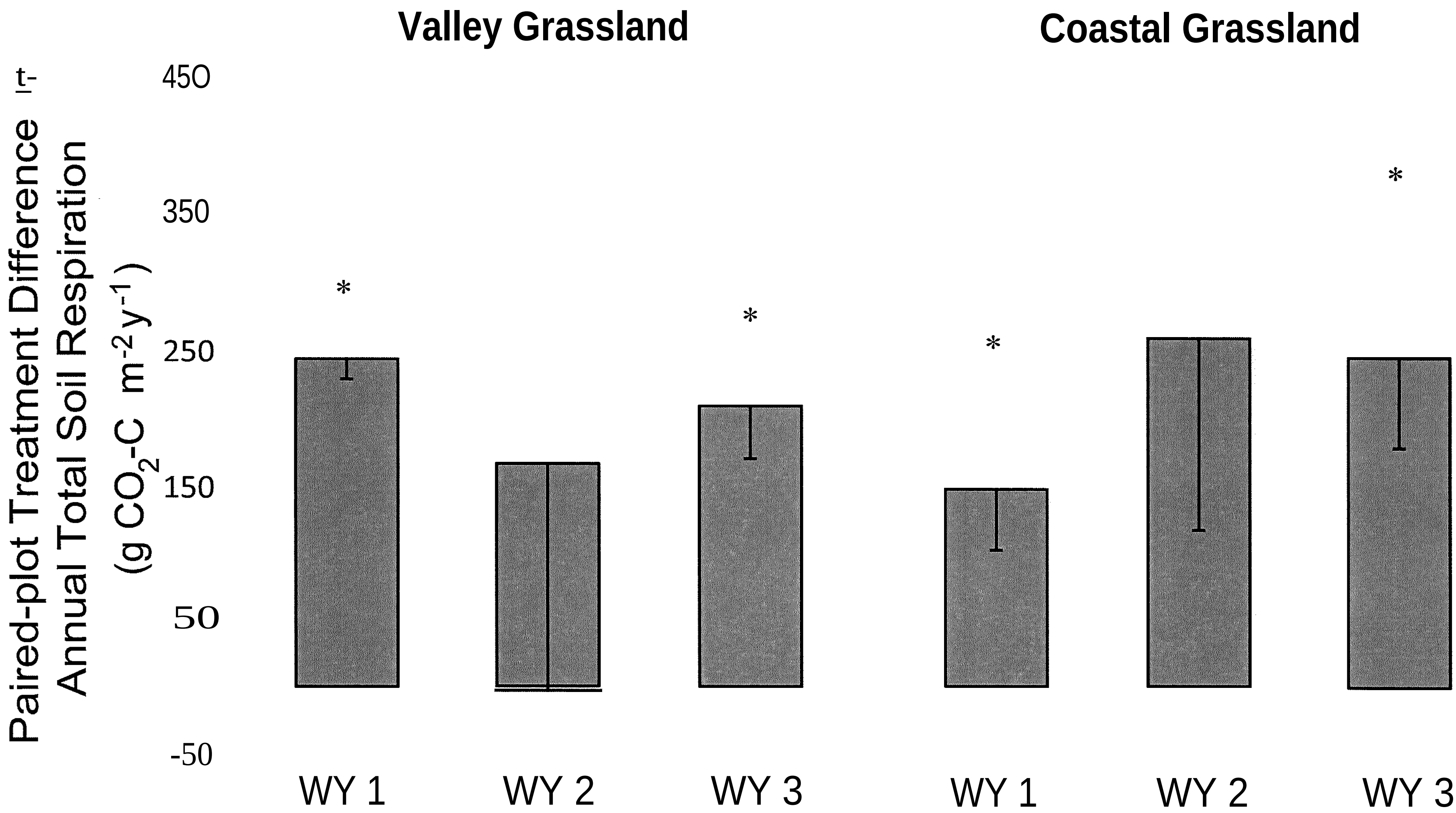
Figure 4. (a) Aboveground net primary production from three water years (WYs) at the valley and coastal grassland experimental field sites. (b) Belowground net primary production (0-20 cm) from three water years (WYs) at the valley and coastal grassland experimental field sites. Root biomass was sampled at 0-10 and 10-20 cm depths. Values are provided in Appendix Table 1. Bars represent paired-plot treatment differences (mean 4- 1 standard en'or). * indicates $p < 0.05$. ** indicates $p < 0.10$.

Figure 5. Net primary production from three water years (WYs) at the valley and coastal grassland experimental field sites. The solid portion of the bars shows aboveground biomass and the striped portion shows belowground biomass in control (white) and amended (black) plots. Data shown as mean 4- 1 standard error.

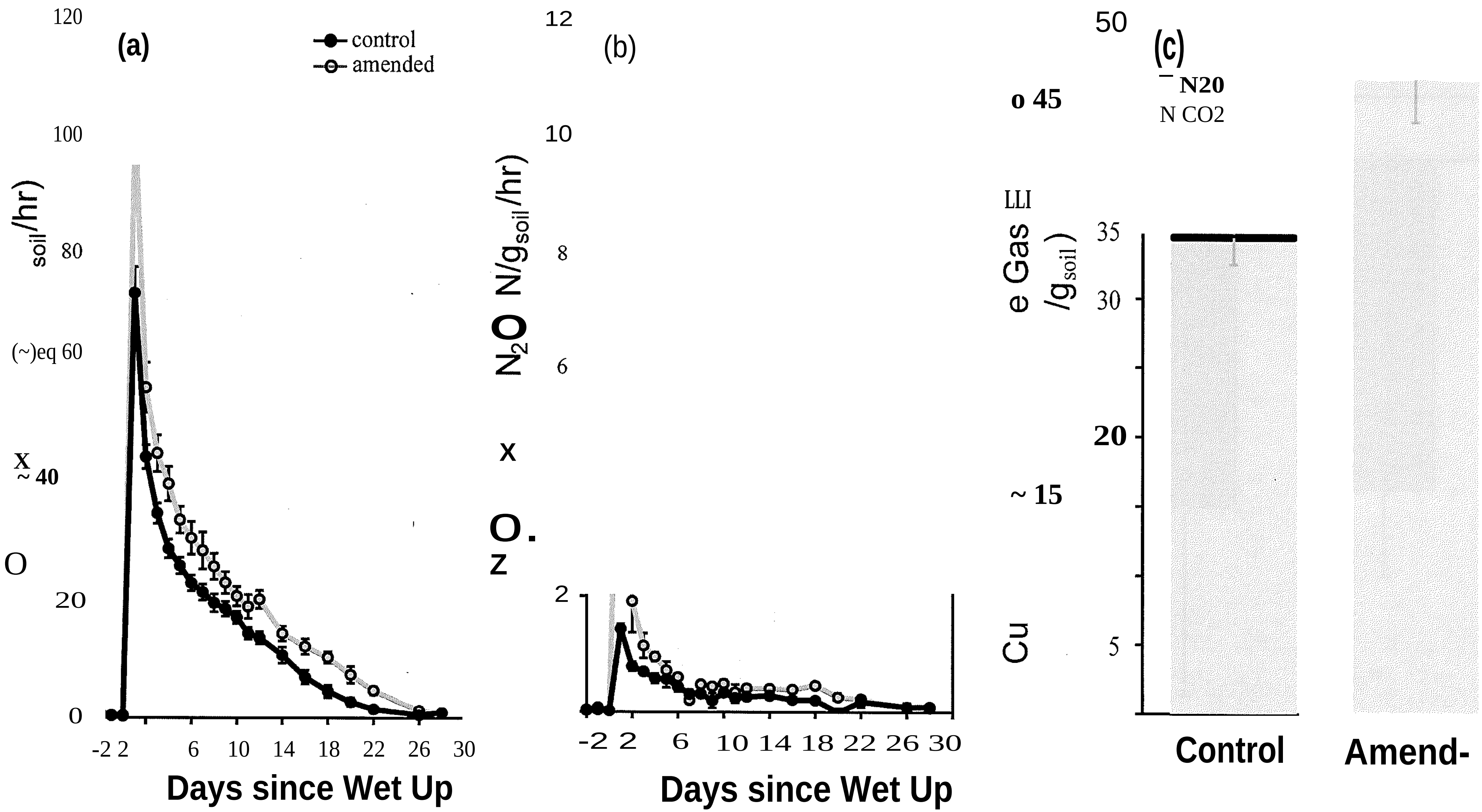
Figure 6. Soil organic C content at 0 to 10 cm data at the valley and grassland sites measured prior to the application (Pre) of composted organic matter and at the end of each water year (WY). Bars are means of paired-plot treatment differences with ± 1 standard en’or bars.

Figure.7. Paired-plot treatment difference in net C storage summed over three water years at the. valley (triangles) and coastal (squares) grasslands sites calculated using low (30 %), medium (50 %), and high (60 %) scenarios of the fraction of heterotrophic respiration to total soil respiration. Each paired plot (n = 3 per grassland type) is shown in a unique color. Errors are ± 1 standard error. Values above zero indicate greater C storage in amended plots compared to control plot. Only one paired plot at the coastal grassland showed consistent C loss in the amended plot.


Valley Grassland
Coastal Grassland
(a)
WY 2008 (380 mm)
WY 2009 (641 mm)
WY 2010 (843 mm)
(b)
WY 2008 (771 mm)
WY 2009 (1050 mm)
WY 2010 (1163 mm)
Precipitation (mm)
Air Temperature (°C)
(d)
Paired-plot Treatment Difference (amended - control)
Soil Moisture (%)
e)
-- Valley Blocks 1,2,& 3
(f)
-- Coastal Blocks I & 3
-- Coastal Block2
CO2 (µmol CO2 m-2 s-1)
(g)
(h)
Time (months)
Time (months)



Valley Grassland
Coastal Grassland
Paired-plot Treatment Difference
Annual Total Soil Respiration
(g CO2-C m-2 y-1)
450
350
250
150
50
-50
*
*
*
*
WY 1
WY 2
WY 3
WY 1
WY 2
WY 3


(a)
control
amended
120
100
80
(~)eq 60
x
~ 40
O
20
0
soil/hr)
-2 2 6 10 14 18 22 26 30
Days since Wet Up
(b)
12
10
8
6
2
N2O N/gsoil/hr)
x
O.
z
-2 2 6 10 14 18 22 26 30
Days since Wet Up
(c)
50
N20
N CO2
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e Gas
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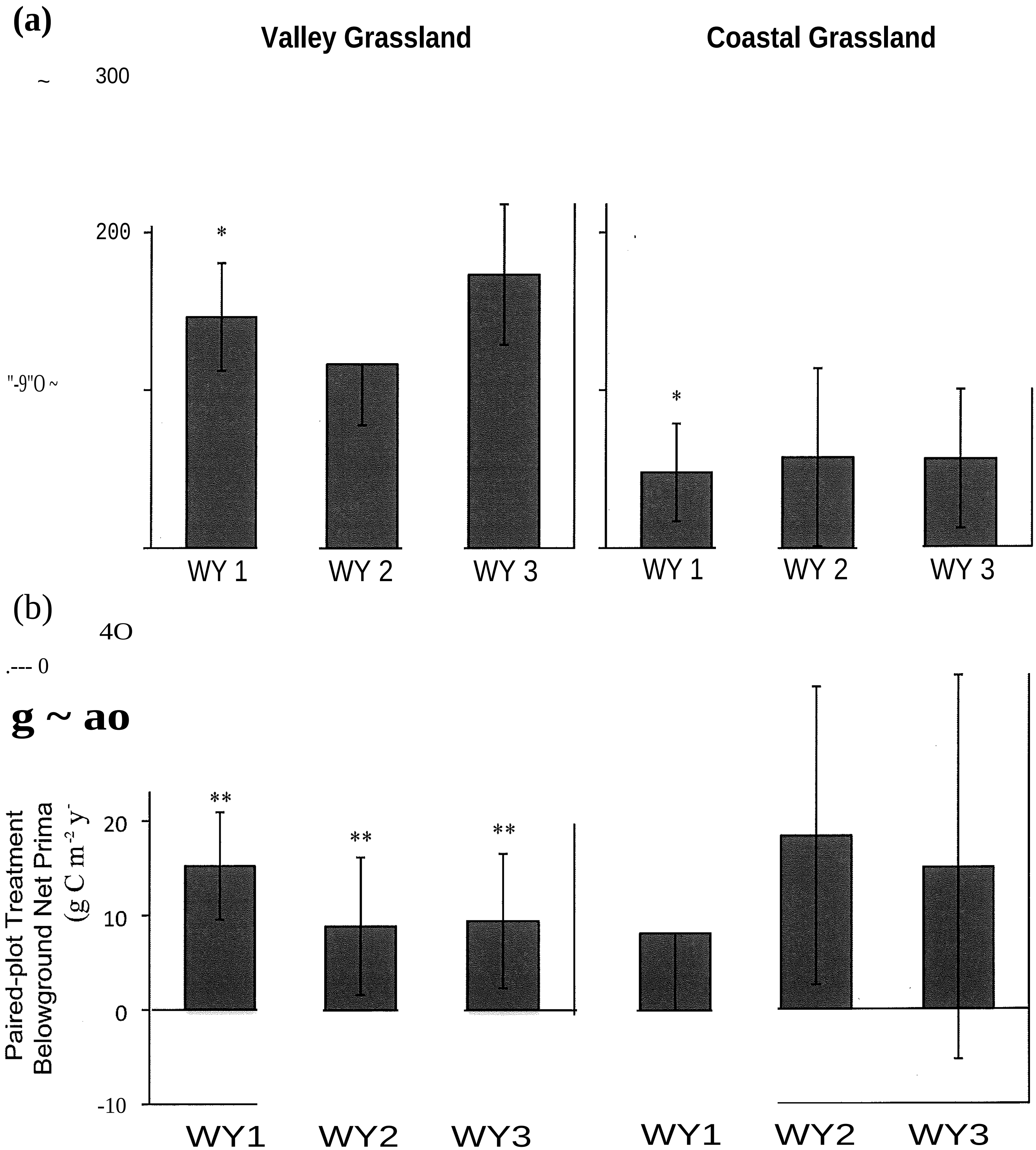
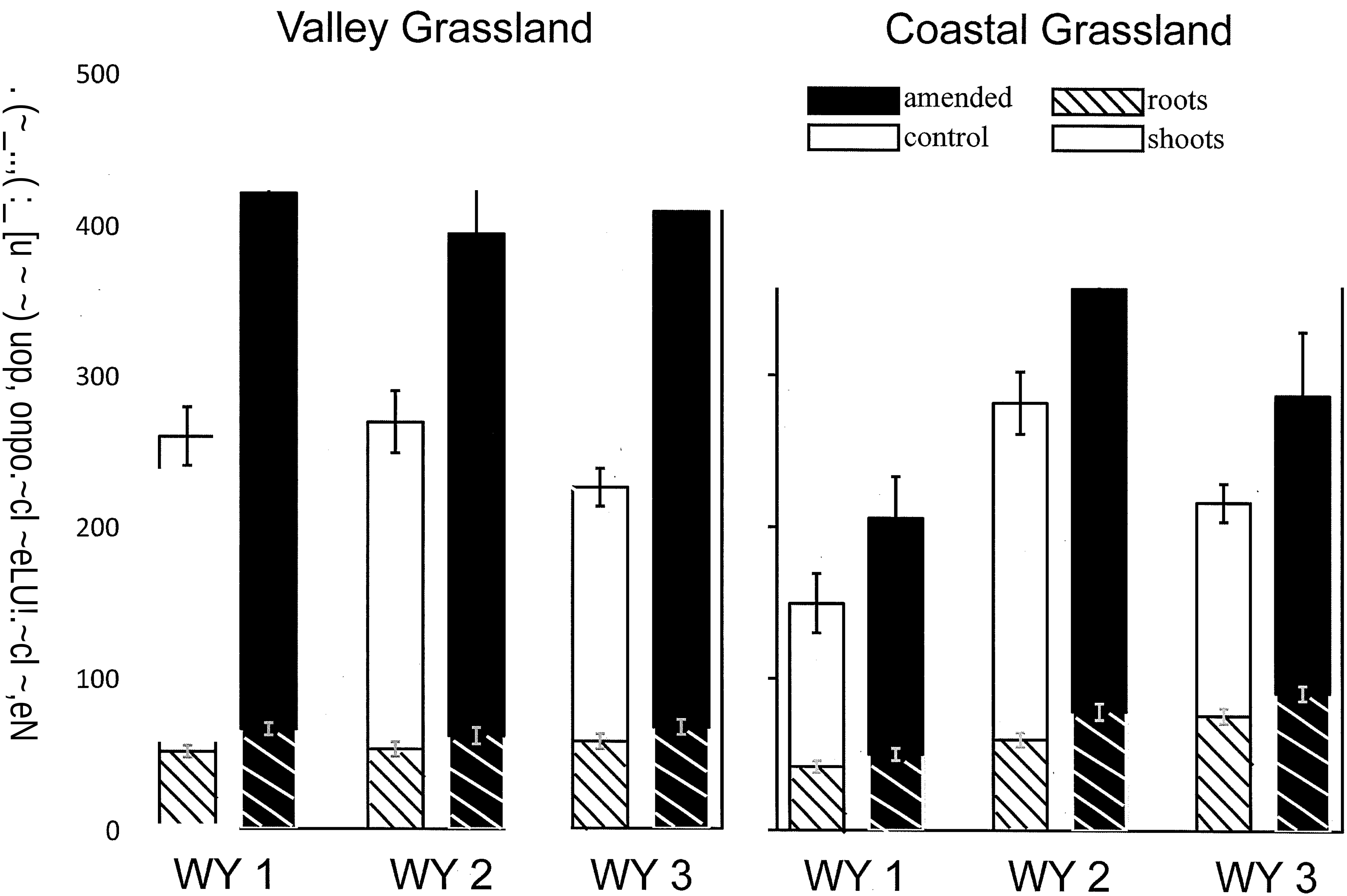
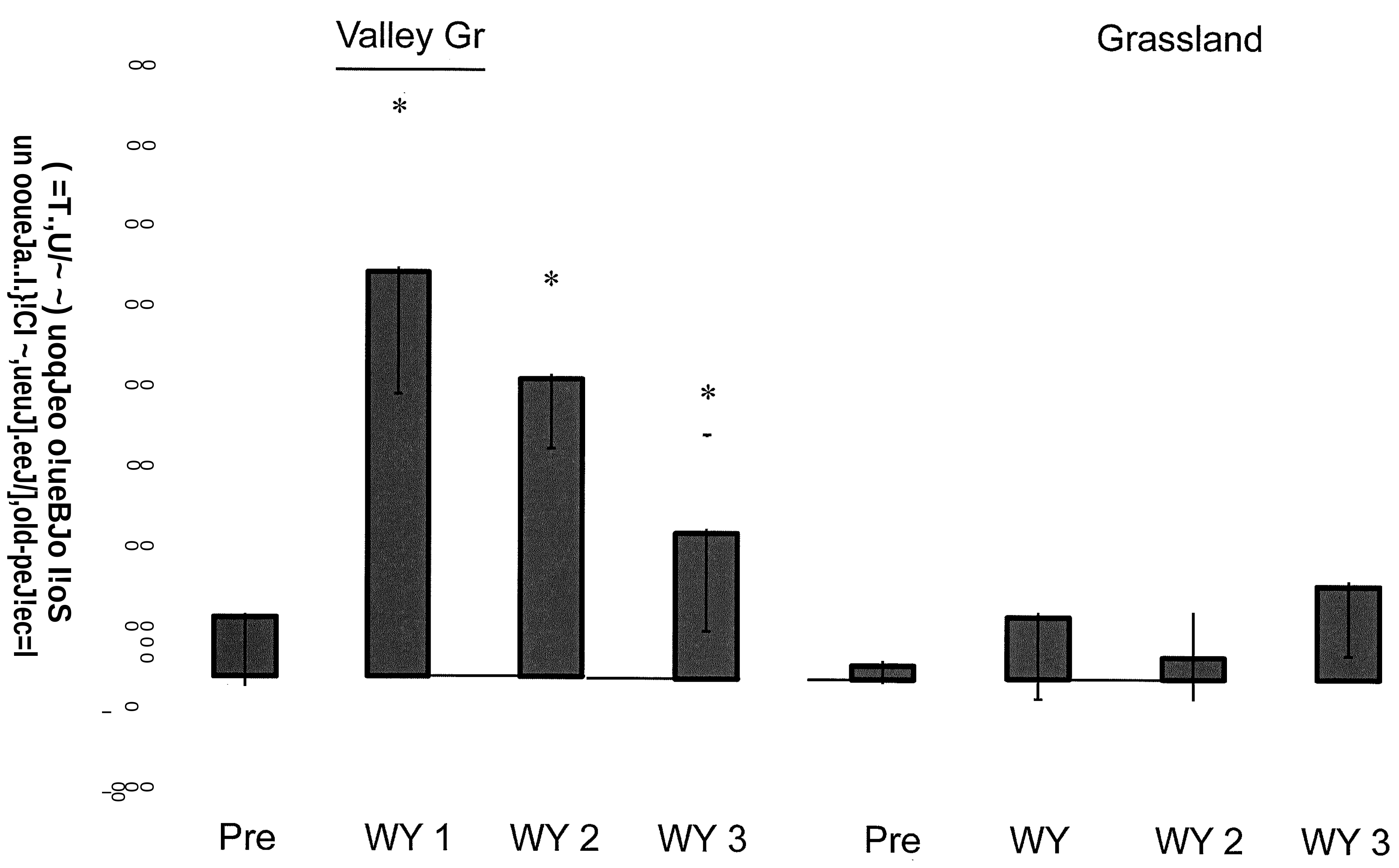
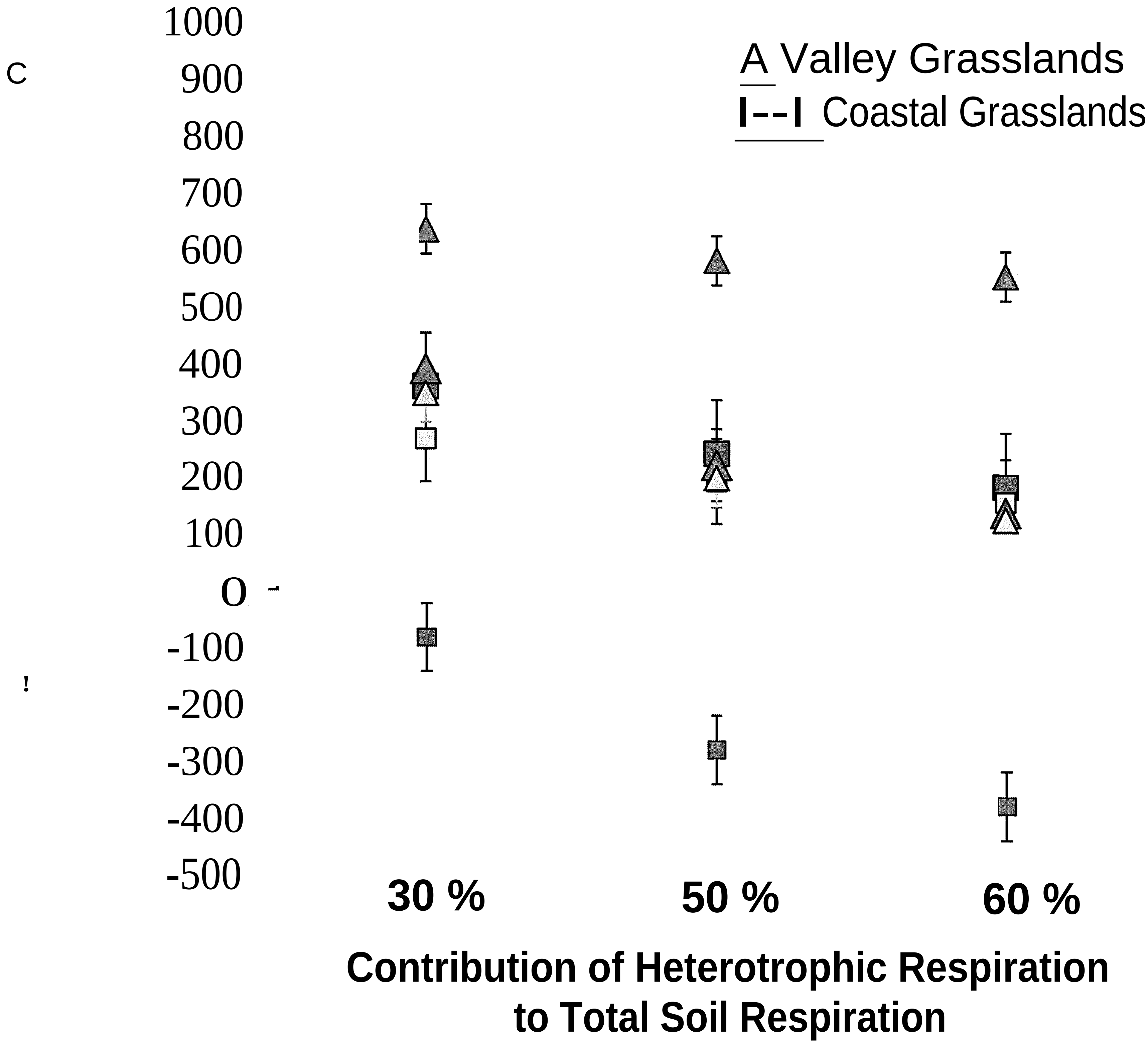
35
30
20
~ 15
5
Cu
Control
Amend-



(a)
Valley Grassland
Coastal Grassland
300
200
WY 1
WY 2
WY 3
WY 1
WY 2
WY 3
(b)
Paired-plot Treatment Belowground Net Prima
(g C m-2 y-
20
10
0
-10
WY1
WY2
WY3
WY1
WY2
WY3


Valley Grassland
Coastal Grassland
amended
control
roots
shoots
500
400
300
200
100
0
WY 1
WY 2
WY 3
WY 1
WY 2
WY 3


Valley Gr
Grassland
Pre
WY 1
WY 2
WY 3
Pre
WY
WY 2
WY 3



C
1000
900
800
700
600
5O0
400
300
200
100
O
-100
-200
-300
-400
-500
!
A Valley Grasslands
I--I Coastal Grasslands
30 %
50 %
60 %
Contribution of Heterotrophic Respiration
to Total Soil Respiration

Appendix D

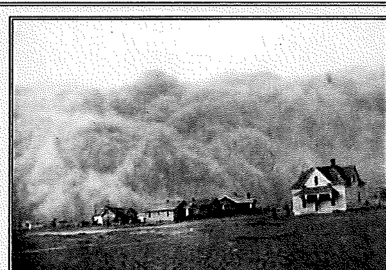
Outreach: Nicasio Landowners Association &

Tomales Bay Association *Presentations*

West Marin
Co-composting
Project

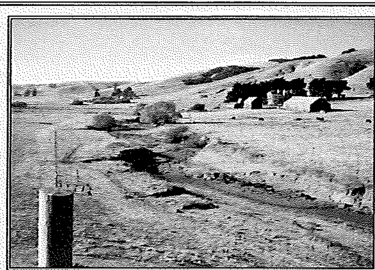
A Project of the Marin Resource
Conservation District

Marin Resource Conservation District?



- RCD's are Special Districts of the State.
- 5 publicly elected RCD Directors.
- District covers primarily West Marin/unincorporated area.
- Funded by local, state and federal grants.
(10% county / 90% state and federal)
- Set up to address soil and water conservation primarily on agricultural lands.

Past Projects



- Watershed Projects – Stream restoration, streambank repair, gully erosion, dairy facility improvement, rangeland management
- Watershed Restoration Plans & Studies – Landowner driven watershed plans, erosion site assessments, geomorphic analysis, vegetation, salmonid surveys
- Restoration Permits – US Fish and Wildlife, Fish & Game, Water Board etc.

West Matin Co-Composting Project

Purpose:

To compost dairy, equine and green waste to promote enhanced soil and water quality. The compost will be used by the partner dairy as a bedding material and sold to local farms, landscapers and residents as a soil amendment.

Funding:

$19,000 County of Marin – examine community concerns, determine permitting and feasibility

$570,000 US Dept. of Ag – planning, design, purchase of equipment, preparation of site

$604,000 Public/Private Matching Funds – provided by Lafranchi/Lunny Families, University of California Cooperative Extension Service, Marin Organic, West Marin Compost Coalition

West Marin Co-Composting Project

Purpose of Presentation:

To introduce the Project to the Nicasio community and provide contact information for questions, comments and concerns.

Where are we in the Process?

1. Secure funding
2. *Organize community work group*
3. Apply for County use permit
4. Secure use permit
5. Set up site
6. Operate compost project in Summer 2008

3 Waste Streams

Dairy

12,000 cubic yards of cow manure currently spread onto dairy pastures.

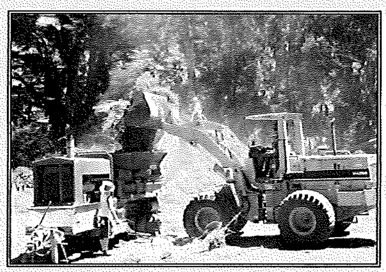
Equine

12,000 cubic yards of horse manure and bedding material currently trucked to Novato, Richmond and beyond.

Green Waste

12,000 cubic yards of green waste currently trucked to Novato and other locations outside Marin.

Step 1



I. Green Waste Delivery

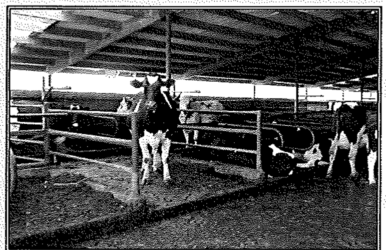
- Green waste is proposed to be dropped off at Nicasio Rock Quarry (Lafranchi owned/Lunny operated) by Shoreline Disposal, landscape companies and local residents by appointment within the vehicle trip limits currently imposed on the quarry.
- Material is ground at a rate of 1-2 hours per week. Noise level not to exceed limits currently imposed on the quarry.

Step 2

II. Composting

- Green waste is transported to Lafranchi Dairy for processing with cow manure.
- Horse manure/bedding material is transported to Lafranchi Dairy for processing with green waste and cow manure.
- Composting occurs on a 40,000 square foot pad.

Step 3



III. Compost Use and Sales

20,000 yards of compost produced annually for:

- Dairy operations as bedding material
- Dairy pasture as soil amendment
- Organic and conventional farmers as soil amendment
- Landscapers as soil amendment

Benefits

•**Water Quality** - Significant improvement in water quality at the dairy and equestrian sites in addition to streams and reservoir. Assist in compliance with water quality regulations.

•**Energy** - Reduce fuel use associated with trucking of organic materials out of the community. Approximately 25,000 gallons of fossil fuels saved annually.

•**Air Quality** - The reduced fuel usage will result in enhanced air quality. The spreading of compost on pastures instead of unprocessed manure improves air quality by a drastic reduction in both odor and ammonia releases. Reduction of potential global-warming atmospheric gases through reduction of fossil fuel usage and methane released from uncomposted organic materials.

Bene_6ts

•**Soil Quality** - Decreased soil erosion and increased water infiltration through increased use of soil-enriching compost; reduction of inorganic commercial fertilizer use in West Marin.

•**Economics** - Increase economic and ecological sustainability of West Marin agricultural operations. Dairy pays less for bedding, equestrian facilities pay less for manure hauling, farmers pay less for trucking of compost.

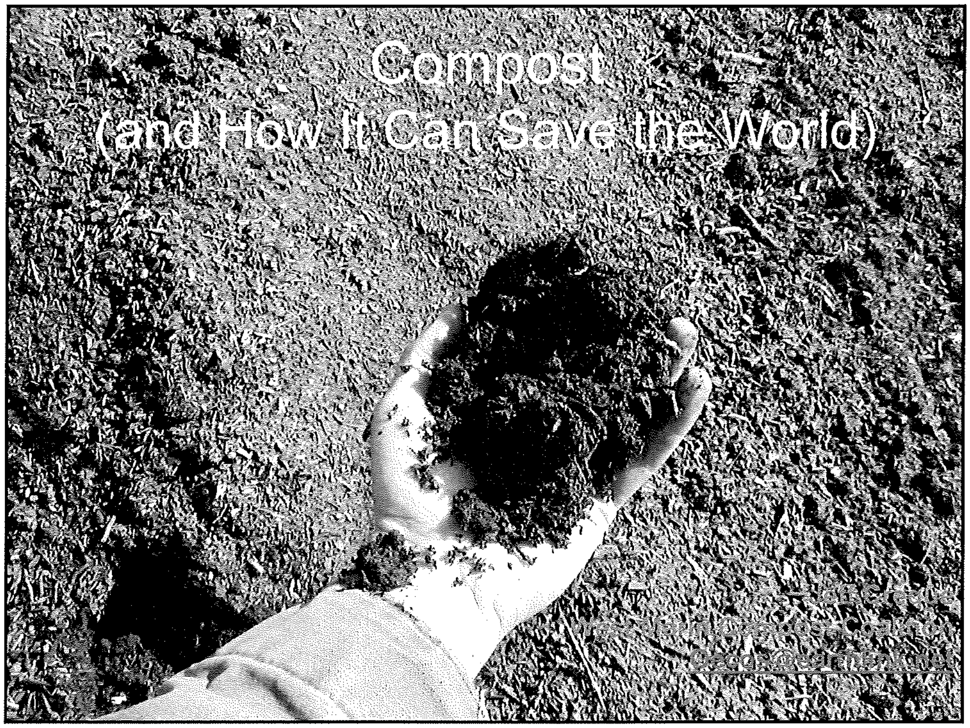
Next Steps

May 16, 2007	Annual Nicasio Landowners Meeting Big Rock Ranch
June	Organized local working group to work with Lunny and advise on project
August	Submit Use Permit application to County
Feb/Mar 2008	Planning Commission Hearing/public testimony

_Please Contact Us

Nancy Scolari
Marin RCD
P.O. Box 1146
Point Reyes Station CA 94956
Phone: 663-1170
Email: nancy@marinrcd.org

Barbara Garfien
P.O. Box 748
Nicasio, CA 94946
Phone: 415-662-2231
bgconnects@aol.com



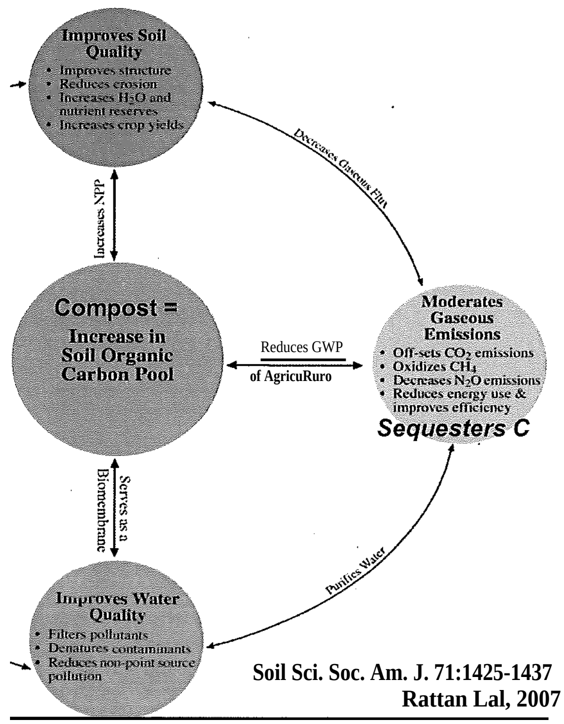
What is Compost?

Compost is *not* a fertilizer.

It is a soil amendment with soil fertility and soil quality enhancing characteristics.

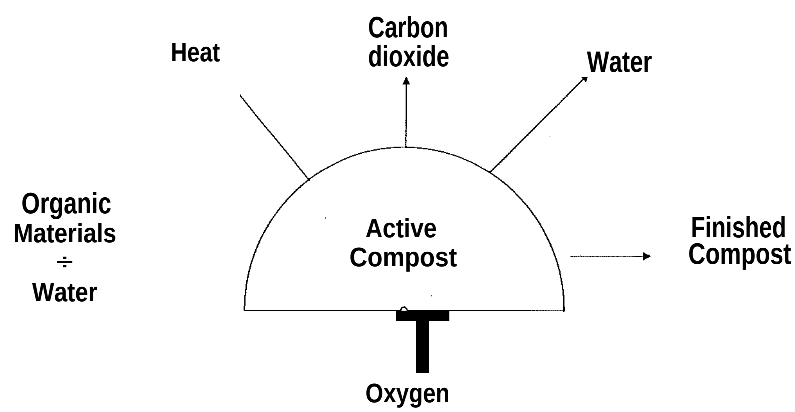
A readily assimilated source of (solar) energy (carbon) for the soil ecosystem that positively impacts soil-plant-water relations.

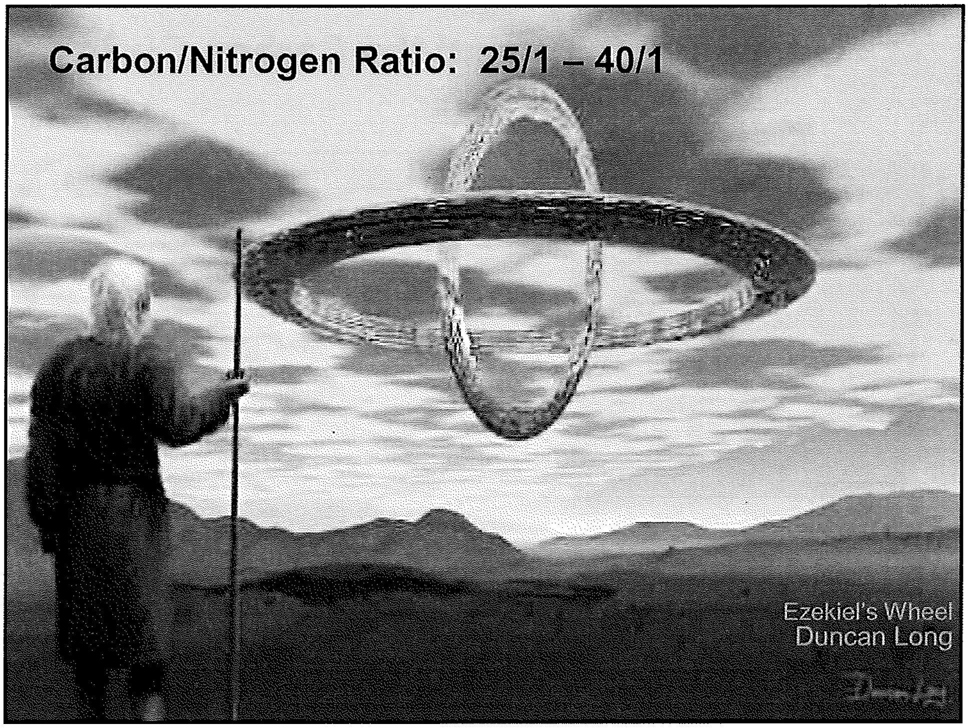
Enhances

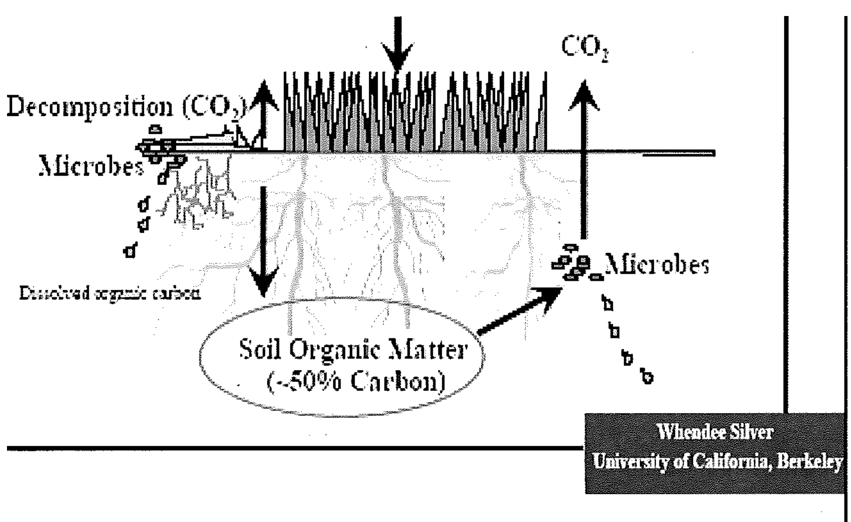


Soil Sci. Soc. Am. J. 71:1425-1437
Rattan Lal, 2007

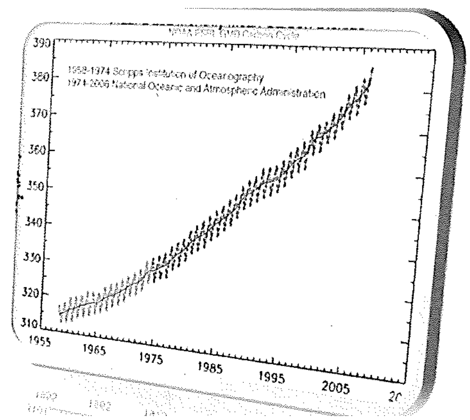
Aerobic Composting Process




Carbon/Nitrogen Ratio: 25/1 – 40/1
Ezekiel's Wheel
Duncan Long


CO_2
Decomposition (CO_2)
Microbes
Dissolved organic carbon
Microbes
Soil Organic Matter
(~50% Carbon)
Whendee Silver
University of California, Berkeley

Global Warming and the Carbon Cycle



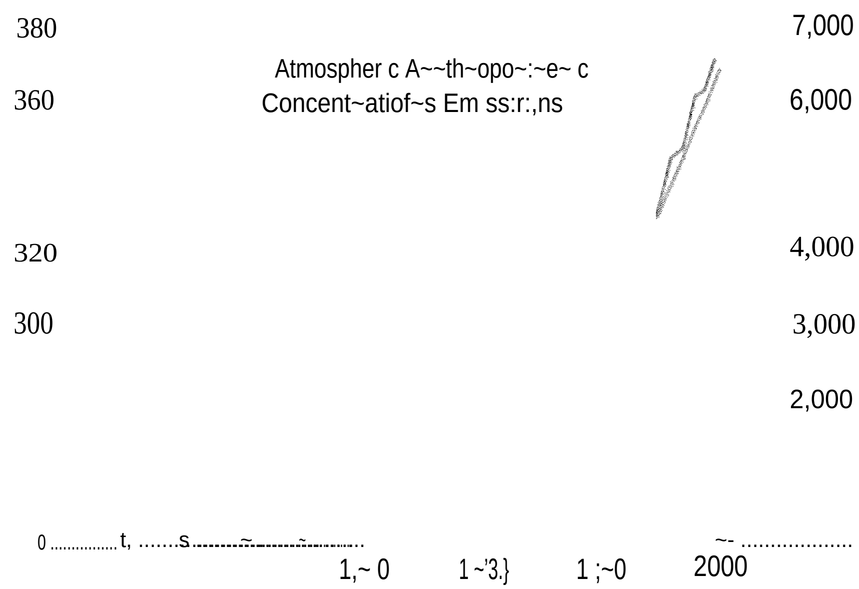
Changes in gJobal average
surface, temperature

Global mean temperature

14.6
142
14,0"
°¢
13.8
t3,6
13.4
13.2

Period	Rate/decad~
100 years	0,074°0
50 years	0,128o0

Eleven of the last twelve years rank among
the twelve warmest years in the instrumental
record of global surface temperature



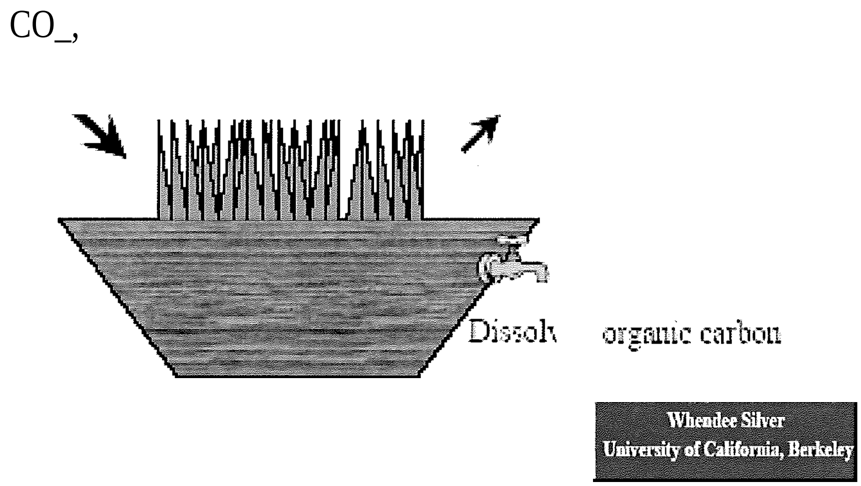
Source: Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center, http://cdiac.esd.ornl.gov/.

Carbon Sequestration

- If we ended all greenhouse gas (GHG) emissions tomorrow, atmospheric CO_2 would take a hundred years to return to 1985 levels. [IPCC, 2007].
- Even the most effective GHG emissions reductions program will not be enough to avoid catastrophic changes in global ecosystems.
- Such programs *must* be accompanied by *carbon sequestration* on a global scale.

Carbon Sequestration :

Carbon Inputs > Carbon Losses



390

370

360

350

340

330 =

320

¥~ar

Excess Carbon Dioxide in the Atmosphere Can Be Transformed Into Soil Organic Matter Through the Processes of Photosynthesis and Decay.

Abe Collins, CarbonFarmersofAmerica.org

Can. Soil Sequestration of Carbon Reverse Global Warming?

- Land area under crop production in the world= 1.5 billion hectare
- Average bulk density of the soil = 1.3 ton/m3
- Average plow depth is 20 cm
- Increasing plow layer soil organic matter by 0.1% (at C content of 58% in ON)= 0.058%/yr

If you multiply all these numbers it is equal to 2.2 billion tons of C/yr going into the soil The total amount increasing in the atmosphere is 3.2 billion tons/yr.

- Thus, increasing soil organic matter by 0.15~/o/yr should offset the increase in atmospheric CO2.This rate can be maintained for 25 to 50 years.
-
- In addition, we have pasture land and forest lands etc. Thus, there is a huge potential for soil carbon sequestration.

-Rattan Lal, pers. com, December, 2007

Bad News" Soil C loss = Atmospheric C gain

- A third or more of the CO2 that we have added to the atmosphere since 1850 has arisen from changes in land use and poor land management practices [Lal, 2008].
- In the same period we have lost 50-80 percent of the organic carbon from our soils. By inference, degraded soils can store *(at least)* up to five times as much organic carbon as they currently hold [Jones, 2006].
- The world's cultivated soils alone are estimated to have lost some 50 Pg C or more from their pre-cultivated condition, suggesting their capacity to hold at least that amount of additional C. -(Lal, 2004)
- The IPCC)has estimated that 55 x 109 Mg (55 billion tonnes or 55 Pg) of soil C have been lost globally largely as a result of cultivating former grasslands, forests, and wetlands (Cole et al. 1996).
- Historical losses of soil C due to cultivation in the U.S. alone have been estimated to be 1.3 $\pm$ 0.3 x 109 Mg* (Kern and Johnson 1993).

"1.3 billion tons **C = 4.771** billion tons C02e
Sou rce: h ttp://www, o rnl. gov/,~we bwo rks/cjAp~/y20~O 1/ re s/111569. D d f

Good News: Soil C Increases can Reduce Atmospheric CO2

'... every one tonne increase in soil organic carbon represents 3.67 tonnes of C02 sequestered from the atmosphere and removed from the greenhouse equation.'

'For example, a 1% increase in organic carbon in the top 20 cm of soil (with a bulk density of 1.2 g/cm3) represents a 24 t/ha increase in soil OC which equates to 88 t/ha of C02 sequestered.'

-Dr Christine Jones (2006), Australia

More Good News"

"Enhancing the natural processes that remove CO_2 from the atmosphere is thought to be the most cost-effective means of reducing atmospheric levels of CO_2." (US Department of Energy)

"Soil represents the largest carbon sink over which we have control. Improvements in soil carbon levels could be made in all rural areas." (Jones, 2006)

An annual increase in global agricultural soil carbon of 0.15% would result in elimination of the current annual net increase in atmospheric greenhouse gases. (Lal, 2004)

"Increasing the soil organic carbon pool by 1 Mg/ha* yr in the root zone can increase production of food grains by 30-40 million tons/yr, and roots and tubers (cassava, yam, sweet potatoes) by 8-10 million tons/yr." Such increases would meet current and projected food deficits around the world (Lal, 2007).

*(1Mg = 1 million grams = 1 metric ton = 2200 Ibs/ha). This is roughly equal to the amount of above ground dry matter recommended for retention as end of grazing year (fall) surface litter on California annual rangelands.

Are our Agricultural Ecosystems Nutrient Limited (eg., Nitrogen), or Energy Limited (Carbon)?

"U. *S. agriculture as currently practiced emits a total of 1.5 trillion pounds of* CO_2 *annually into the atmosphere. Converting all U.S. cropland to organic would not only wipe out agriculture's massive emission problem.., it would actually give us a net increase in soil carbon of 734 billion pounds."*

-The Rodale Institute

– *In the near term, carbon sequestration projects on agricultural lands are the easiest and most readily available means of offsetting greenhouse gas emissions on a meaningful scale.*

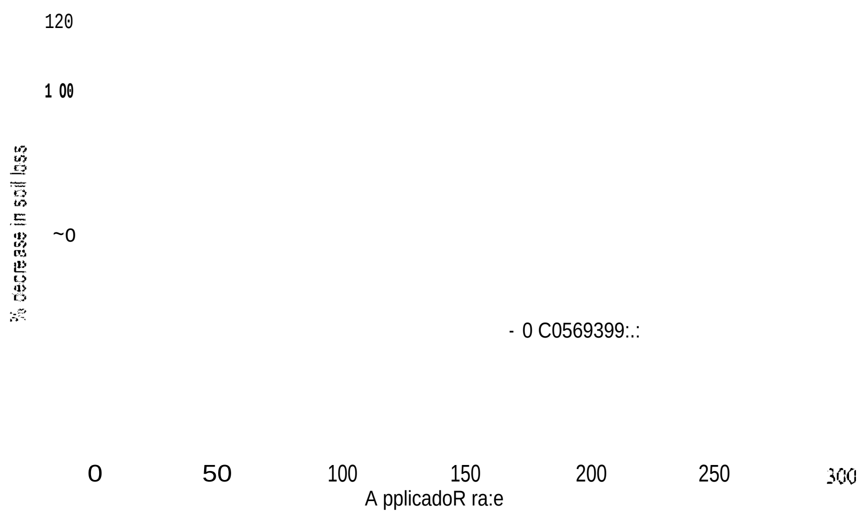
-US EPA

– at least 50 percent of the Earth's land area is available for, and in need of, strategies that sequester carbon, restore ecosystems, increase yields and improve food security.

Compost can make a significant contribution to reversing the flow of carbon to the atmosphere by optimizing conservation of biologically fixed carbon and facilitating sequestration of carbon in the world's soils.

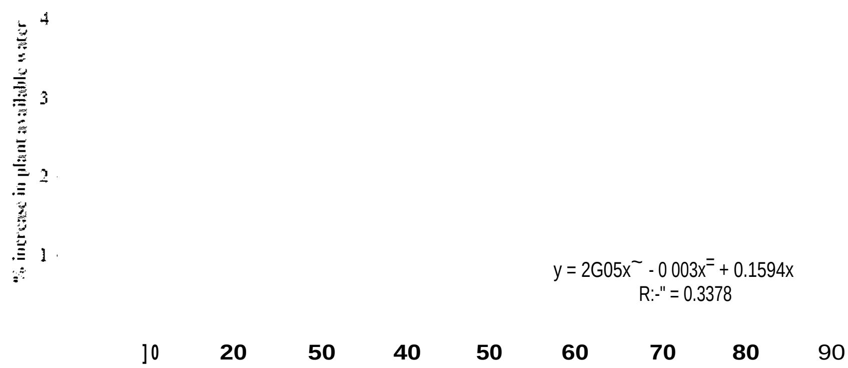
Effect of compost on soil erosion

Recycled Organics Unit *Life Cycle Assessment for windrow composting systems* 2nd Edition 2007



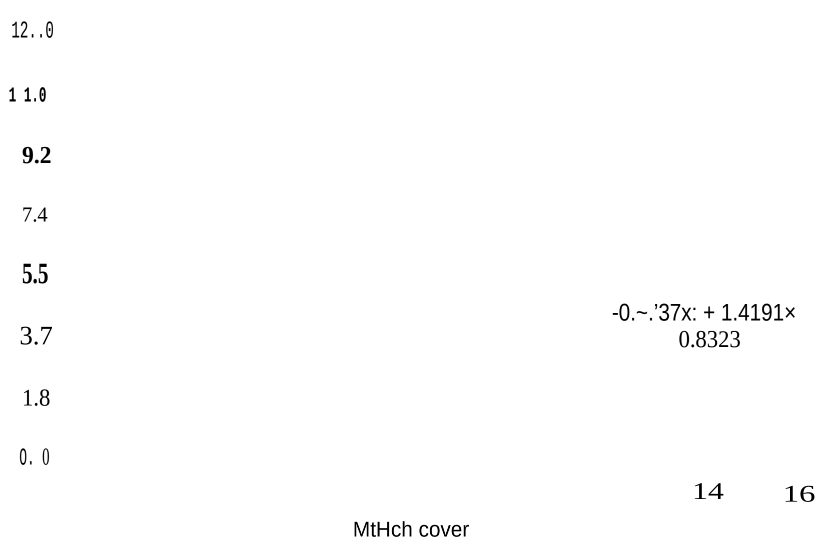
Effect of compost application on soil moisture (0- 15 cm layer)

Recycled Organics Unit *Life Cycle Assessment for windrow composting systems* 2nd Edition 2007



Effect of compost mulch on soil moisture of 0-15 cm layer.

Recycled Organics Unit *Life Cycle Assessment for windrow composting systems* 2nd Edition 2007



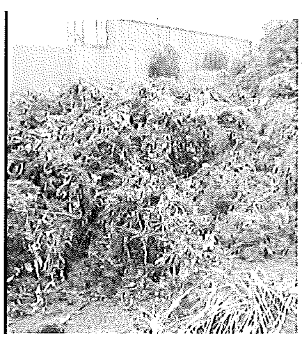
The solution to the inextricably linked global crises of

- food security,
- water availability and
- climate stabilization

lies in the soils beneath our feet.

COMPOST!

West Marin Composting Project



Appendix E

l~edia: Newspapers, Magazines and Recognition

California State Assembly

Certificate Of Recognition

PRESENTED TO:

Matin Resource Conservation District

West Marin Agricultural Co-Compost Project Inauguration

Presentedto honor Matin Resource Conservation District's West Man'nAgricultural Co-Compost Project Inauguration. Through collaboration with many ¢ocalandstate partners, including Lafranchi Dairy, Matin Organic, UCCE, and the Marin Agn'cultu~'al Commissioner, this project willdemonstrate composting as a toolfor enhancing the environmentalandeconomic sustainabi£ty ofagn'culture in West Mann andthe Bay Area at large. Thankyouforyour outstanding conservation efforts.

October 28, 2011

MEMBER OF THE ASSEMBLY
CALIFORNIA STATE LEGISLATURE

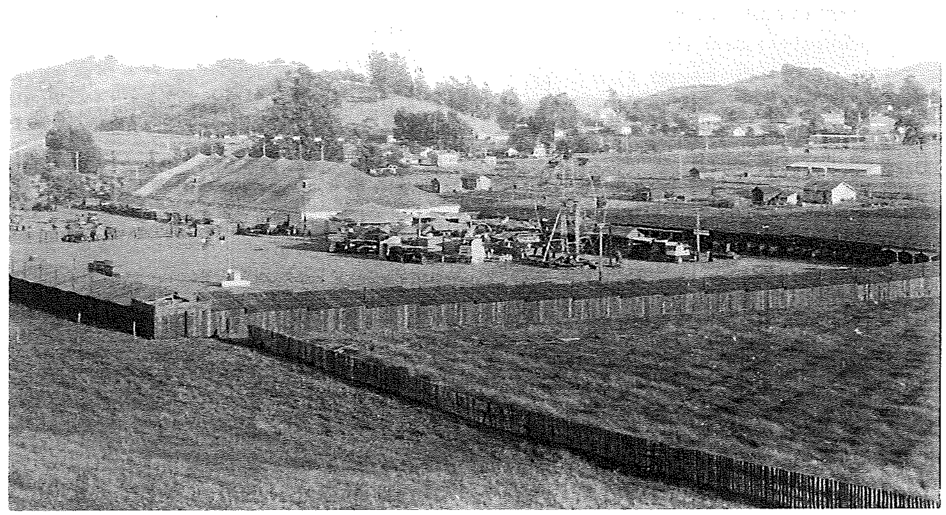
New Roots of MARIN COUNTY FAIR REVEALED!

For years, it was believed that the Marin County Fair origiriated at the Marin Art & Garden Center in Ross in 1946, but new historical research has revealed that our beloved fair actually had its beginnings in Novato in 1925! As we celebrate the 2ooth anniversary of agricultural fairs in North America, we are thrilled to learn that the agrarian roots of the Matin County Fair go back to the i92os.

Thanks to photos and information from the M.B. Boissevain photography exhibit that will be at this year's fair, this wonderful discovery has been made!

The first Matin County Fair and Harvest Festival was actually organized in i925 by Novato residents as a county-wide event and fundraiser for the Community House, and was held on September z8, 19 and 2o of that year. Boissevain wrote about the fair, saying:

Livestock here composed the principal exhibits, and the S. C. White Leghorn exhibit of utility birds was the big end of this show. Nearly 1000 birds were shown and judged purely on a utility basis. The best breeders in the Petaluma district exhibited, and Professor James Dryden, judge of the show, said he had never handled a finer lot of birds.... Fruits, vegetables, flowers, home canned goods, *needle, and art work were all exhibited here.*



The Marin County Fair site was located on a large undeveloped property west of Redwood Highway between Grant Avenue and Olive Avenue. To take the picture, Boissevain stood on a hill to the northwest of the event; today the location is on Pinheiro Circle above Ranch Drive in a new Novato subdivision, until recently part of the Pinheiro family ranch.

From farm animals to a Ferris wheel, Novato Ag Club to 4-H, this fair was held annually until I928, when the last one was held in Novato. The 1925 fair was held on First Street in Novato and the following year it moved to the present site of the Pinheiro Ranch subdivision on Novato Blvd., owned originally by John Atherton.

Back then the fair was produced by a broad-based community association with support from Matin County and Marvelous Marin. After a gap of ~7 years in i946, a new fair was created at the Matin Art & Garden Center in Ross, called the Matin Art & Garden Show. It was run by a group of non-profit community organizations. In ~95o, the official County of Marin-sponsored Marin County Fair, first at the Ross location and then at Matin County Civic Center, began a run that continues today.

WEST MARIN COMPOST

We are proud to have.West Marin Compost supplying the soil for the Matin Master Gardeners educational gardens and for the Professional Landscape Gardens. West Matin Compost, located in Nieasio Valle~ keeps everything they do local by producing high quality compost from three community waste streams: dairy, green and equine.

The West Matin Compost project is a community-driven solution that benefits the environment, the agricultural community, the county and the local community in numerous ways. It helps agriculture meet water quality standards, provides an organic soil amendment for farming and gardening, and provides horse stables an ecological alternative for equine waste and bedding material. In addition, it gives Marin dairies locally produced low-pathogen bedding material.

Un~versiW of' California

West Marin's community compost project

West Matin Compost (WMC) is a community compost project that has been steadily turning .out finished compost at the Lafranchi Dairy in Nicasio since February 2012. Ten years in the making, this public/private partnership' was initiated through the efforts of the Marin Resource Conservation District (Matin RCD) with a significant portion of this project's fundingfrom the USDA Natural Resources Conservation Service and Lunny Grading and Paving,][nc.

JeffCreque, Erika Hughes, Loretta Murphy, Kevin Lunnyand Joe Lunnygatherfora photograph at the opening of the West Marin Compost Project,

The project engaged the Matin RCD, the West Matin Compost Coalition, Matin Organic, UC Cooperative Extension, Lafranchi Dairy and essential logistical and financial support from the County of Marin through the efforts of Marin District 4 Supervisor Steve Kinsey. The West Marin Compost project addresses West Marin's need for a local, environmentally sound strategy for managing its organic residuals, while restoring and enhancing the fertility of its rangeland and agricultural soils. At the same time, the project models a solution to the growing climate crisis.

Soils have a uniquely important role to play in mitigating and reversing the accumulation of greenhouse gases in the atmosphere. Through the solar-powered process of photosynthesis, growing plants absorb carbon dioxide from the air, and move that CO_2 to the soil as beneficial soil organic matter in a process known as soi! carbon sequestration. Soil carbon sequestration, in conjunction with essential emission reductions, offers the safest, fastest, most beneficial and effective means of addressing global warming, while at the same time helping to buffer agricultural and other managed ecosystems against the negal:ive effects of climate change.

Composting organic,"carbon-based" waste materials offers one of the simplest and most efficienl: means of conserving and sequestering atmospheric carbon captured by plants. -I-he controlled composting environment transforms relatively ephemeral plant carbon into a more stable form (compost), which means less CO2 going back to the atmosphere than if that vegetation was left to decompose on the soil surface. Transferring stabilized carbon and associated nutrients to the soil as compost provides a source of slow release energy and nutrients for the soil ecosystem and growing vegetation, while helping to protect both soil and water quality. Once applied to soil, some compost carbon ends up in long-term soil carbon pools where it can be expected to stay sequestered for decades or centuries, all the while enhancing soil fertility and water holding capacity. This in turn means enhanced plant growth, accelerating the rate at which plants can pull CO2 from the air, driving further reductions in greenhouse gases.

The climate change benefits of producing compost from organic materials that would otherwise end up in landfills are especially significant. This is due to the avoidance of methane emissions associated with anaerobic decomposition of organic materials in those landfills. In addition, a local organic materials recycling facility means significantly fewer haul miles travelled on West Matin roadways, with less fossil fuel used in the counter-productive transport of those valuable soil building materials out of the region. Returning West Narin’s organic matter and nutrients to West Narin’s.soils has significant implications for enhanced function of West IVlarin’s watersheds and sustained productivity of its agricultural lands.

How it t,~orks

WlVlC makes compost from three primary West Matin resources: clean green materia~ equestrian facility residuals and dairy manure. Green material is collected and ground at the West Matin Compost green material drop off site, located at the Harin Hunicipte Water District yard across the street from lVlarin’s Department of Public Works yard on Nicasio Valley Road. Equestrian materials are collected via WNC’s roll-off dumpster service. For a modest fee, WiVlC will drop off an empty dumpster at your facility, and pick it up for recycling of its contents on an as-needed basis.

Once ground, green material is hauled to the compost site on the Lafranchi Dairy where it is blended with equestrian materials and dairy manure, and watered as needed to initiate the high temperature composting process, 13y maintaining temperatures of i31 F of higher, for 1_5 days or more, high temperature composting eliminates virtually all pathogens and noxious weeds. The composting process typically continues for 30 to 60 days. The material is then stockpiled and allowed to mature for a month or more before being offered for bulk sale as both screened and unscreened material.

WMC compost is produced in compliance with National Organic Program standards, and is in the process of being certified by the Organic Naterials Review]:nstitute (ONR0.]:n the meantime, anyone using WMC compost on certified organic acreage or crops can request a letter of documentation from WMC. Bagging of finished compost is planned for the near future.

The drop off site is open for business from 12-4pm weekdays and 9-1pm on Saturdays. Drop off charges are $25 per cubic yard, Only clean green materials are accepted. Chipped materials are accepted for a lower per yard fee.

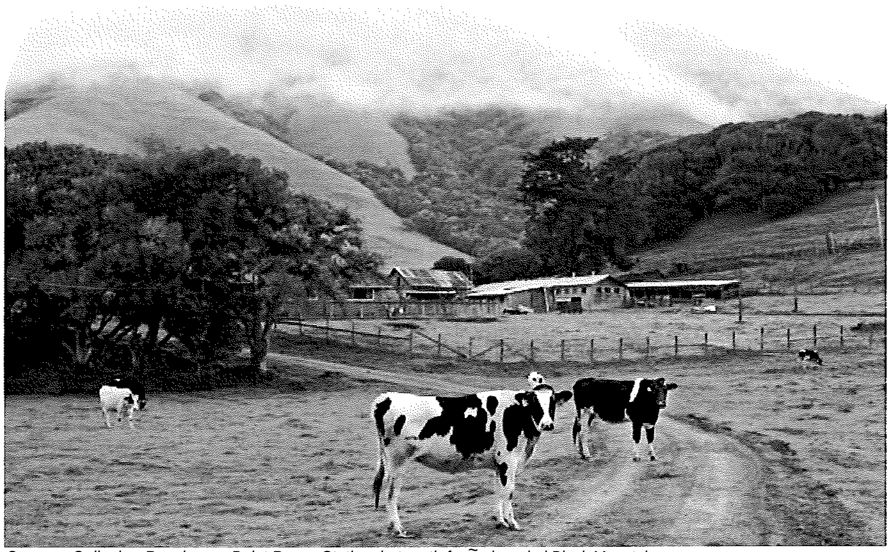
For more information about the project, drop off hours, equestrian services or to purchase compost, \?.,! ,~,~ t_. can be reached at 41.5-662-9849.

"" "Exy[arin in Frands Area

Mail sent.

The Grass Really Is Greener

Storing Carbon in Rangeland Soils



Cows on Gallagher Ranch near Point Reyes Station, bet~eath fog~ shrouded Black Mountaia,
© Kathleen Goodwfn, ka thleengoodwin.ne~.

by dacoba Charles -- published April 24, 2012

On a windswept ranch above the tiny West Marin town of Nicasio, a man in a worn Carhartt jacket holds up a blade of grass with a triumphant smile. This is rancher and philanthropist John Wick, and he's explaining how he hopes to help save the world using an unexpected tool: dirt.

Specifically, Wick and his partners at the Marin Carbon Project think that if ranchers make a few simple changes to their ranching practices, then massive amounts of greenhouse gases could be removed from the air and stored in the soil of their pastures. For a long, long time.

In an era marked by mounting greenhouse gases yet few practical solutions, the idea of sequestering carbon in the soil is so simple it sounds too good to be true. Soils have long been known to be one of the world's largest pools of carbon. Yet when we think of places to store carbon, we tend to picture dense forests--not open grasslands--as the ideal landscape type. It's time to think again.

The possibility that restoring grassland soils could serve to capture atmospheric carbon on a similar scale as planting trees was largely theoretical until 2007, when Wick and rangeland ecologist Jeff Creque first discussed it. They invited top UC Berkeley biogeochemist Whendee Silver to do a quantitative study, and within months the Marin Carbon Project was born, with Wick volunteering his ranch for the experiments. Members of the team include the USDA Natural Resources Conservation Service, Marin Organic, and the Marin Agricultural Land Trust.

Rancher John Wick talks about Ihe Matin Carbon Project to a group of climate change researchers and agency officials on a site visit at Iris raoch in Nicasio, Ftloto by Torn Forster. courtesy Marin Carbon Project

"People understand that agriculture produces greenhouse gases, but don’t realize that it can also be a big part of the solution," says Torri Estrada, director of the project.

Four years in, the data emerging from the experiments is more clear-cut than anyone had expected. The main experiment began with spreading a single thin layer of organic compost on the test plots in a pasture--and the next year the soil had more carbon. And the next year, and the next.

"It’s pretty incredible," says Silver. "[The amount of carbon] continues to grow more year after year. We basically have increased the production in the system up to a new level."

Three years ago, the team spread a half-inch blanket of compost on the soil surface of the test plot. Today, 90 percent of that material remains on the surface, acting like a slow-release fertilizer and helping to build soil organic matter. And the underlying soil has gained a metric ton more carbon than similar areas nearby that wore left alone. Some of this additional carbon came from the compost, and some is likely to have come from plant growth that was stimulated by the compost. The team’s computer models suggest that a single application of compost could lead to carbon storage for up to 30 years.

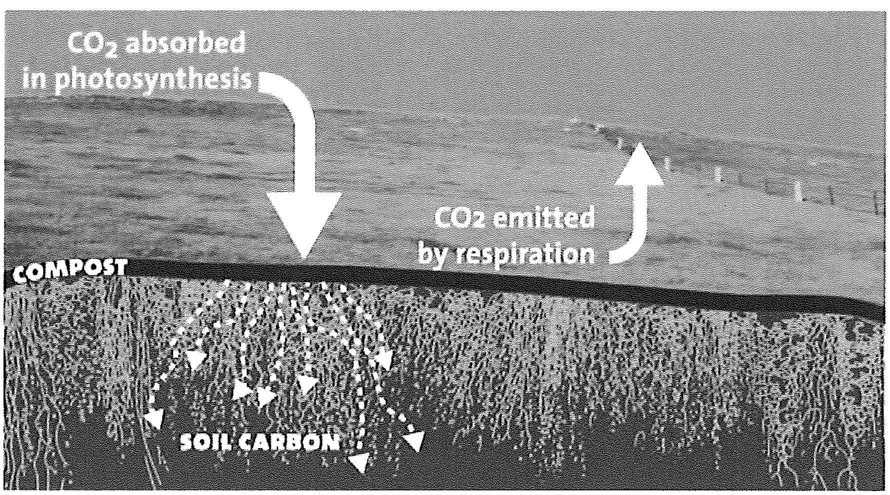
If this turns out to be true, spreading compost on half the 23 million acres of rangeland in California every three decades could offset all carbon emissions from all commercial and residential use. For good.

Down the road from Wick’s ranch, the experiment has been repeated in another field, volunteered by a local dairy rancher. From a distance, the pasture just looks like a pasture. A gate of fence posts and wire opens onto a field with low-cropped grass and scattered cow pies. But a closer look reveals the telltale signs of a field science experiment: There is a small solar-powered electrical box, and rectangular plots are marked with brightly colored tufts of flagging.

Look closer still, and you can clearly see the effects of the compost. Standing out on the green backdrop of the pasture are patches of darker green. The grass is kept short by the cows, but in some areas the plants clearly have glossier, broader leaves that are a deeper shade of green than their neighbors’. These are the places where compost was spread.

"We saw a big increase in forage production every year, and wo saw a big increase in the roots too," Silver says.

In other words, plant growth is very much connected to soil carbon storage. Each grass blade and iris leaf acts like a tiny vacuum, sucking carbon out of the air and transforming it into the solid structure of the plant’s body. The more the plants grow, the more carbon they need--and the less carbon is left in the atmosphere to contribute to climate change.



Carbon dioxide absorbed by grasses through photosynthesis is sequestered in the roots and surreueding soil. The corl~ost layer increases the amoant of carbon absorbed by the plants, relative to the amount released back into the atmosphere. &~stration by Bay Nature. adapted from Whendee Silver, UC Berkeley,

Rangelands are an ideal place to store carbon because much of the grasses’ growth--and hence the initial carbon sequestration--is belowthe ground in the form of roots, where it can readily be transferred into more permanent storage in the soil. Trees and other plants also store carbon, but they grow more slowly. And they keep more of their biomass above the ground in the form of trunks, stems and leaves--where it is vulnerable to wildfire and human uses, which return stored carbon more quickly to the air.

Because most of our local (mostly normative) rangeland grasses grow quickly, produce lots of roots, and die every year, they are particularly good at pumping carbon into the soil. When a plant decomposes, the remnants of its roots and leaves stay in the soil, breaking into tiny particles. As those particles work their way into the soil, they get trapped, and the deeper they are, the longer they tend to stay. Some linger near the surface, where microbes turn the plant carbon back into a gas; but some get embedded in clumps of soil, where they can stay for decades. And some particles go deeper still and chemically bond with the soil. When that happens, the carbon can be trapped for centuries.

"When it gets deep into the soil it would take a fairly disruptive event--plowing, for example--to bring it out again," says Estrada.

Every year the soil at the research plots is tested by taking core samples down to a meter below the surface. Portions of each sample are then put into tiny tin capsules and dropped into a high-tech furnace back at the lab at UC Berkeley. As the soil burns, sensors measure the amount of carbon released. And the findings? Consistently more carbon is present in the soils treated with compost. "It works--that's the bottom line. The thing flies," says Wick. "This is a success story." Now the challenge is to scale it up and entice ranchers to join up by turning sequestration into a source of revenue for them.

Behind a dairy ranch on the outskirts of Nicasio, pile upon pile of compost stands in tidy rows. This project of the Marin Resources Conservation District is another arm of the Marin Carbon Project team's work: blending local green waste and manure from nearby ranches to create the compost needed to expand a science experiment into a farming technique.

The compost is important not only because it helps the plants grow;, simply creating it is good for the planet. Today, a lot of green waste, manure, and other organic material goes to landfills or into manure ponds on ranches. There it gradually decomposes under anaerobic conditions, actually becoming a source of the extremely potent greenhouse gas methane. Yet when the same material was spread on Wick's ranch as compost, almost no greenhouse gases wore released.

In fact, it turns out that those gases that don't get generated in a landfill are the biggest benefit in the Marin Carbon Project's carbon account book.

Getting ranchers to actually start spreading compost is the next goal of the project. "We hope to make that jump this year," says Estrada. "Thus far it's been a controlled experiment. Now we are looking at how to make this simple and easy to do so that the ranchers can really own it."

"1 think it's a really good idea," says Mike Giammona, a cattle rancher near Point Reyes Station. "The problem is the cost factor. Buying compost is really expensive; with what we get for running beef cattle, it's not worth it right now financially."

Providing financial incentive has been a goal of the Marin Carbon Project since the beginning. By developing a method through which soil carbon levels can not only be increased but also monitored, the project has been laying the groundwork to participate in emerging carbon markets. The project team is nowworking with the Environmental Defense Fund to develop a protocol that will meet state standards and let interested businesses and investors partner with rangeland owners on efforts to meet greenhouse gas reduction requirements,

But several hurdles remain. The protocol to verify howmuch carbon has been sequestered must be developed and approved. Then some organization or agency has to come forward with the staff to do the monitoring. Interested ranch managers need to be trained in the technique. And high-quality compost has to be made--a lot of it.

But the potential is significant. George Lucas's Skywalker Ranch is one local business that proposes to offset 500 metric tons of greenhouse gas emissions per year. The hope is to account for much of that through rangeland carbon sequestration; several regulatory agencies are currently considering the proposal.

If the project can succeed in facilitating an economic reward for greenhouse gas reduction and carbon storage on California's ranches, it will be an exciting step toward ensuring the preservation of iconic rural landscapes and communities, "The idea is that wo would offer producers and landowners a suite of practices that have a carbon benefit," says Estrada. "The endgame is to have a real impact on farms *and* on the climate."

Learn more at marincarbonproiect.org

Science writer Jacoba Charles grew tip lending sheep on her family's Sonoma County ranch. Her t~ork has been published h] the New York Times, on Salon, corn, and elsewhere.

This article is part of our "Climate Change: Dispatches from the Hotne Front" series, takhTg you to the front lines of efforts lo uaderstand aed adapt to the local impacts of climate change. The series is sapported by the State Coastal Conservancy. The Nature Consetvancy, Pacific Gas & Electric, and PRBO Conservation Science.

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Add New Comment

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than the soil

March 8, 2012 The Citizen

By Jeff Creque, PhD

As the first batch of West Marin Compost rolls off the compost site at the Lafranchi organic dairy in Nicasio, the need for and importance of the project has never been more apparent. Over 10 years in the making, the public/private partnership between the Marin Resource Conservation District, Lunny Grading, and many other partners, represents the capacity for West Marin to meet its needs for an environmentally sound outlet for its organic residues and for a strategy to both restore and enhancethe fertility of its rangeland and agricultural soils.

As accelerating global climate change makes itself ever more evident to all but the walking dead, the role of soils in helping to mitigate, and even reverse, the accumulation of green house gases in the atmosphere is increasingly recognized. By transferring harmful excesses of CO2 from the atmosphere to the soil as beneficial organic matter, soil carbon sequestra'tion offers the single safest, fastest, most beneficial and most effective means of addressing global warming, while at the same time helping to buffer agricultural and other managed ecosystems against the unpredictable effects of climate change, including increased aridity, increased erosivity of storm-driven winds and rain and increasingly unpredictable weather.

Research conducted in Nicasio and the Sierra foothills by UC Berkeley biogeochemist Dr. Whendee Silver under the auspices of the Matin Carbon Project has quantified the effects of relatively small applications of compost to West Marin rangelands: more forage production, greater water holding capacity and moderated soil temperatures have all been documented, along with a significant increase in long-term soil carbon pools. Meanwhile, control plots continue to lose carbon to the atmosphere, a trend observed on rangelands globally for reasons as yet uncertain. The implications of the Carbon Project's results for slowing, and even reversing, global warming are significant. World renowned soil scientist Rattan Lal has suggested that an increase in soil organic matter of only 0.16% in the world's arable soils alone would effectively sequester all of the excess CO2 now in the atmosphere, driving global warming.

To understand the process by which atmospheric gases become soil organic matter, one needs to look to the miraculous process of photosynthesis, by which green plants use sunlight to transform CO2, water and a small quantity of minerals and nitrogen into their own structures. Thus air is made solid, the ingredients for food, flora, fuel and fiber are made manifest, and carbon is transferred from the atmospheric pool to the soil pool, via plant roots and the decay of plants .and animal matter at the soil surface. Composting offers one of the most efficient means of capturing and conserving this transformed atmospheric carbon, by processing it to a stable state (compost), and transferring that stabilized carbon and associated nutrients to the soil system as a source of energy and nutrients for the soil ecosystem.

Decades of local experienc~ with strategies to enhance soil organic matter reveal just how easily Lal's 0.16 % increase could be realized, and compost offers perhaps the simplest and quickest way to achieve -and exceed- that objective. If that compost is produced from organic materials that would otherwise have gone into landfills, the impacts are even more significant. Enter West Marin Compost.

As demonstrated by the Bolinas-Stinson Beach Resource Recovery Project over the past 15 years, the organic material steam of West Marin is much great than is generally recognized. BSBRRP has. processed over 100,000 cubic yards of west Marin landscape and arboricultural materials since the closing of the Point Reyes dump in 1996. Almost all of that material has originated in the communities of Stinson Beach and Bolinas, with the remainder of West Maria having to haul its material over the hill to San Rafael, Petalnma or Novato, or dispose of it illegally in empty lots or along roadsides. West. Matin now has an environmentally beneficial alternative: the West Marin Compost (WMC) green material drop off site at the MMWD yard across the street from the DPW yard on Nicasio Valley Road. The site is open for business from 12-4 weekdays and 9-1 on Saturday. Drop off charges are $25 per cubic yard. Only clean green materials are accepted.

West Marin equestrians now have a local alternative to hauling their materials over the hill as well, by taking advantage ofWMC's roll-offdumpster service. For a modest fee, WMC will drop off an empty dnmpster and pick it up as needed.

These materials, plus organic dairy manure from the Lafranchi dairy, are blended to initiate the thermophilic (high temperature) composting process. By maintaining temperatures of 131 F or higher for 15 days or more, thermophilic composting eliminates virtually all pathogens and noxious weeds. The composting process then continues for 30 to 60 days, before the fmished material is allowed to mature for a month or more, before being offered for sale.

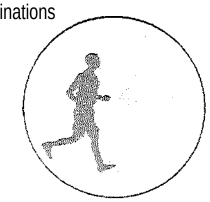
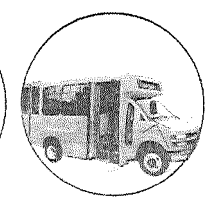
WMC compost is produced in compliance with National Organic Program standards, and is in the process of being certified by the Organic Materials Review Institute (OMRI). Meanwhile, anyone using WMC compost on certified organic acreage or crops can request a letter of documentation from WMC.

For more information about the project, drop off hours or equestrian services, West Marin Compost can be reached at 415-662-9849.

Join us at our inaugural compost event: Compost at the Commons, Saturday March " lOth in Point Reyes Station, 10 AM- 1 PM. We're excited about sharing our first batches of finished compost with west Marin gardeners, farmers, and landscapers.

Daily transit service to popular destinations including:

~ Mt. Tamalpais State Park
~ Stinson Beach & Bolinas
= Fairfax & San Geronimo Valley
— Pt. Reyes National Seashore
= Pt. Reyes Station & Inverness

West Marin Stagecoach

West Marin Citizen

REDWOOD EMPIRE DISPOSAL

out

By Lynn Axelrod

The Board of Supervisors Tuesday approved a 6.74 percent rate increase requested by The Rat-to Group, owner of Redwood Empire Disposal. The major reason is a 35% increased fuel cost. Ratto's franchise agreement with the county calls for an automatic adjustment each January 1 for the next three years, based on a Refuse Rate Index.

Redwood also will begin a new food waste recycling program of vegetables, meat, dairy foods, and food-contaminated paper products. The weekly collection will be composted with residential green waste. The Marin Hazardous and Solid Waste Joint Powers Authority calculated that 49 percent of residential waste going to landfill is food waste and other compos~able organics.

After the vote, Supervisor Kinsey said, "All the raccoons in the Valley will be high-riving each other" over the clean waste. The cost to customers will be 40 cents of the total $2 increase per 32-gallon can. Redwood Empire serves all of West MaNn, except for Bolinas and Stinson Beach.

Pacific leatherbacks can grow up to nine feet long and generally are visible off the Marin coast in summer and fall. They have declined more than 95 percent since the 1980s, with only some 2,300 adult females known to exist.

Commission begins wrapping things up

The County Planning Commission met Monday to address carryover issues from its previous seven meetings. A small public audience attended.

Commissioners restricted ground-based Wind Energy Conversion Systems (WECS) to placement on agricultural parcels. The maximum allowed height remains at 100 feet.

Regarding vegetation removal, they turned away a staff recommendation to extend county rules into the Coastal Zone because the county code is limited to native trees and exempts agricultural lands. The Commission wants to include other vegetation and felt a blanket exception for agricultural lands would not work in this largely agricultural area, Commissioner Wade Holland explained.

They discussed keeping the cost of a vegetation removal permit at an affordable rate, roughly $150, and requiring applicants to take out only a coastal permit, not both coastal and county permits. The issue will be rediscussed at their next meeting.

See • News Briefs page 13

The Citizen's Forum
Page 4 • West Marin Citizen • October 14, 2010

GARBAGE RATES HIKE 11 PERCENT

County grows West Marin green waste plan

By Andrea BlUm

A PROJECT FOR DEALING WITH GREEN WASTE in West Marin spearheaded by Kevin Lt{nny of Lunny Grading & Paving Inc. and Drakes Bay Oyster Company received a $400,000 boost this week with county. Supervisors' approval of a new contract for Redwood Empire Disposal.

The con[ract and a drop-off site are at the center 0f.the long-awaited . " iprgjec~ that has been in the plhnning stages for years

Supervisor Steve Kinseyhamme~ed out a de~l " "~ " ..... '"'" " Conservation District, Lunny and Redwood EmpWe,ththe tMathiaResnerce- ing:West Marin

The contract says that Redwood Empire would put up $400,000 for necessary equipment as well as agree to haul the green waste t6 a recyclifig site in Nicasio in exchange for the county renewing its contract expiring on June 30, 2015.

The-hauler, in turn; was granted permission to charge customers an additional 11 percent. The rate increase amounts to $2.37 more per month for a 32-gallon can, on average. The hauler uses three different rates for dif-. : ferent regions of West Marin~ and the ! 1 percent increase is an average.

"The rates are still the lowest in the county;' said Michael Frost deputy director of the Department of Public Works.

The rate hike, said Steve McCaffery Director of *Government* Affairs for Redwood Empire Disposal, will also allow them to buy and modernize their fleet with energy efficient vehicles with "split bodies" to collect different Mnds of waste, reducing the number of trips.

In the meantime the RCD still has a $565,000 USDA grant to help fund the project aS long as they can secure a drop-off site. The county is workmg out a way: to provide a county-owned site located a4ross Nicasio Valley Road from the public works'corporation yard.

See ¯ GREEN WASTE PAG~ 7

I lrle Site IS aown me roaa [roilt txx~.

Lafranchi Dairy the location of the proposed West Marin compost project that would combine three waste streams from green to cow and horse manure to create West Marin's own compost facility. The resulting compgst would provide nutrient-rich soil for organic farmers and gardeners.

Last month, Kinsey met with the Community Development Agency, Department of Public Works, and county counsel to discuss the proposed drop-off site.

"We reviewed the project plans and confirmed the County's interest in the project given its consistency with our agri-. cultural, zero waste, and vehicle mile reduction goals;' Kinsey said. "Public works agreed to take the lead in bringing the proposal for the county to act as the lead public agency for the drop-off facility - given the advantages our sponsorship offers the RCD. The county has inherent

RCD would need to prepare and administer several complicated land use applications."

The project has taken years to organize and should go before the Board of Supervisors by the end of October. "It's been years in the making to get to this point. There is no hold up. It's just that nothing is easy;' Frost said. "But there is still no contract. It's not done yet:'

Erika Hughs-Rels, watershed director of the Marin RCD said they are waiting for the county to secure the drop-off site.

'~After working on legal issues in concert with adjacent landowners, MMWD and DPW will bring the matter before the full Board in October;' Kinsey said.

In the meantime, Kevin Lunny said he was excited about the forward movement. "It has been a long ride but with all the effort it will be a great thing;' he said. "We are on the final stretches:'

KINSEY GIVES FULL SUPPORT

By i\ndrea Blum

It's been seven years of trial and error to get the Nicasio-based Mario Cornposting Project off die grotlild, Finally ii appears the innovative scheine lo combine three slreanis of Wesl Matin wasle locall7 - instead of filling up Redwood l=andfill - might be on a rol!,

At a Matin Resoucce (]onservation District meeling last week, Supervisor Steve Kinsey gave his full support to the projed and said he will pusl~ hard lo [~llld tl~e shortLdl of $,100,000 to get tl~e project up and running.

"The cotinty coukl take care of that funding;' said Kinse7 who listed a variety of reasons why the project would be a public benefit. Among the reasons he stated were improved water quality, benefits to the dairies, a local alternative for equestrian **waste,** reducing the carbon footprint as well as creating a carbon **sink with** the compost product, reducing landfill waste and helping to build a model for other areas. "I believe that there **is a good possibility with assistance, the county could fill that hole7**

Kinsey said the money could **go through the RCD who would** transfer the money to the project. He also indicated that the RCD could become a beneficiary **to** the project.

The composting project would take three different .West Matin waste streams and turn them into local resource. The resulting compost would provide uutrient-rich soil for ranchers, organic farmers and gardeners and a source of bedding for cows. The compost center would also help horse stables comply wida water quality requirements in the Tomales Bay water shed.

Currently, i'nost West Marin green waste is hauled to tile Redwood Sanitary l.andfill in Novato, some of that waste is shipped to the Central Valley, while local dairies like tile l.afranchi's truck in sand fl7Ol13 tile Central Valley for bedding in Ihcir Ioafhlg barns,

COW MATTRESS

The prdjecl hit many snags along the way. One key isstie inwflved the organic l.aFranchi Dairy-- a partner ill Ihe busi hess and tl~e chosen location o1: the project. One of tile benefits of the compost would be to supply bedding for the l,aFranchi dairy cows. ltowever, the COlnposl used as bedding would need lo have a very low moisture content in order to be; sal~ lbr the resting cows. AchieVing tl{~ low percentage of moisture needed lbr **the** bedding is slill an unknown. Although carbon and soil specialisl]elf Creque almost guaranteed that ti!e required moisture content of 25 percem or less could be achieved, the I,aFranchi's prefer a safer alternalive. "The concern is satZ'ty of **our** cows and to make our operation even better~' said Rick Lafranchi,

In lieu of the bedding, Kevin I,unny along with his allied partners in the business, Inverness resident John Wick, and Creque said they would provide rubber mattresses. But the cost, $110,000, proved untenable tbr the underfunded project.

What's more, newer air quality regulations **and concerns** require the **composting** equipment to be state of the art instead **of** used. Those factors pushed the **funding** shortfall even **higher to** the estimated $400,000, Lunny said.

But last week, **with conditions to** come **up,with a sustainable plan, Kinsey reassured** the district and the **composting** partners that the county would pay for the mattresses and the **funds for** the equipment including a grinder and a loader.

A USDA grant of $569,250 for the project and the in-kind match provided by the county, Lunny, Wick and Creque is **not** enough lo get the project ruuning. However the USI)A grant has been e~tended by two years, buying some time.

The p.riority at this point, said Kinsey to the stakeholders, is to get tile permits in line from the Calil't)rnia Integrated Waste Ma,~agement Board and Air Resources Board.

Kinsey left the meeling suggesting that the stakeholders reach an agreement **on** managing the permit process and clarify ctmditions with the Marin R(]I) with in one ll/Ollt h.

1 tc also suggested a joiill meeting at the courtly hi brainstorm ideas for the project to be succcsslul and have a product by 201 I.

"Things were looking bleak but the **sun** is shiiufing today(> said Kinsey.

Appendix F

Marketing: West Matin Compost website

clear 3" from top
.5" from each edge

WEST MARIN COMPOST

Nicasio Blend

MADE WITH PLANT & ANIMAL MATERIAL

RECOMMENDED USE

POTS / FLATS
Use 90% West Marin Compost with 10% sharp sand, or use 100% West Marin Compost Drakes Bay Blend

GENERAL GARDENING
Add 1-2" of West Marin Compost to the soil surface before planting.

ROW CROPS
Incorporate 35-70 tons/acre before planting, or side dress with 10-35 tons/acre

ORCHARDS
Broadcast 10-30 tons/acre

TREES, SHRUBS AND GARDEN PLANTS
Amend planting hole soil with 25-50% West Marin Compost

MULCH
Use 2-4" of West Marin Compost

PASTURE
Broadcast 10-35 tons per acre

SITE RESTORATION
Mulch or incorporate 1-4" of West Marin Compost into top 2-6" of soil

What is Compost?
Compost is the product of the managed microbial decomposition of plant and animal materials into more stable forms suitable for beneficial application to soil. Active compost reaches temperatures of 131° F to 170° F for not less than 15 days, during which time, the material is turned a minimum of five times in order to insure exposure of all the material to these high temperatures. The compost is allowed to mature for another 60-90 days before being screened and bagged.

The West Marin Compost Story
West Marin Compost is a public-private community project addressing a wide range of environmental issues in West Marin County and beyond, including reducing atmospheric CO^2 through soil carbon sequestration, improving soil and water quality, recycling green waste, reducing fuel use and increasing farm and garden sustainability.

West Marin Compost
5575 Nicasio Valley Road
Box 730 Nicasio, CA 94946
ph: 415 662 9849

REGISTERED cdfa ORGANIC INPUT MATERIAL

Ingredients: Compost (composted dairy and equine manures, wood shavings, chipped plant material)

1.5 CU. FT. / 42.47 LT.

PURPOSE: SOIL QUALITY IMPROVEMENT
THIS COMPOST COMPLIES WITH USDA NATIONAL ORGANIC PROGRAM STANDARDS
THIS BAG IS RECYCLABLE, MADE WITH 25% POST INDUSTRIAL MATERIAL AND WATER BASED INKS. PLEASE RECYCLE

WWW.WESTMARINCOMPOST.ORG

WEST MARIN
COMPOST

5575 Nicasio Valley Road *ph:* 415 662 9849

about west marin compost

West Marin compost produces high quality compost from three community waste streams: dairy, green and equine.

The West Marin Compost project is a community-driven solution that benefits the environment, the agricultural community, the county and the local community in numerous ways:

Keeping it local- closing the loop: Currently green and equestrian waste material is trucked out of west Marin to facilities in east Marin or beyond. Diversion of west Marin organic waste materials away from landfill disposal to reuse within West Marin will benefit all Marin residents.

A tool for agriculture to meet water quality standards: Hundreds of tons of nutrients are purposefully imported into the region each year in the form of inorganic and organic feed and fertilizers. Some of these have the potential to contribute to the concentration of nutrients in West Marin surface waters. A local organic soil amendment will reduce the need to import nutrients from beyond west Marin, and thus reduce the potential for excess nutrients to end up in surface waters. Making and using compost locally provides agricultural operations with a tool to help them meet recently established TMDL water quality standards. Compost is vital to organic farming, and the number of organic acres is increasing in Marin County.

Providing an organic soil amendment for organic farming: Because finished compost is a dry material it is much less costly to apply to land than wet manure. Finished compost is odorless and much less mobile under rainfall conditions than manure. Properly composted material does not contain viable weed seeds, which liquid manure often does, so spreading compost does not spread thistles or other weeds. Centralizing the composting process allows for the purchase of expensive composting equipment, often cost prohibitive for individual farms.

Providing Marin dairies with a locally produced low-pathogen bedding material: For more than 100 years, West Marin dairies have utilized beach sand as a low – pathogen-bedding material. As of 2006, this sand is no longer available. The west Marin compost project provides Marin dairies with an economically viable, locally sourced bedding solution. The bedding material we produce is made by co-composting dairy waste with low bulk-density equestrian and green wastes and produces a superior bedding material. This locally produced material has the added benefit of reducing economic and environmental costs associated with hauling imported bedding materials.

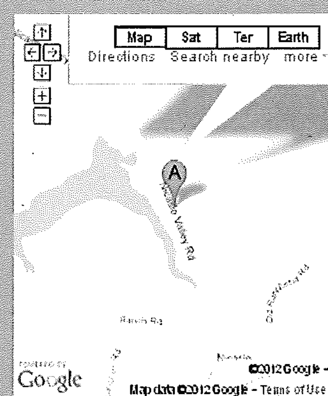
West Marin Compost is a public-private partnership between:

Lunny Grading and Paving, Inc.
Lafranchi Dairy and Marin County

Technical assistance is from:
the West Marin Compost Coalition

Administrative assistance from:
the Marin Resource Conservation District (RCD)

Funding support from:
USDA Natural Resources Conservation Service Conservation Innovation Grant
Lunny Grading and Paving, Inc.
The Rathmann Family Fund
Redwood Empire



WEST MARIN COMPOST

5575 Nicasio Valley Road *ph:* 415 662 9849

got greenwaste?

Please call 415 662 9849 for information about dropping off your clean green material.

The green waste drop site is open to the public five days a week HRS: *(map on right)*. Drop off site is open from 12-4 Monday to Friday and 9-1 Saturday. The drop-off fee provides essential long-term financial support for the Project and is competitive with alternative green waste disposal options for West Marin residents, while reducing the time and fuel needed for trucking to east Marin disposal sites, or beyond. Please note: It is illegal to put toxins into greenwaste cans or dispose of them in any but an approved toxic waste facility. Each load is inspected; contaminated loads are not accepted. If contaminants are found following off-loading, the driver will be required to immediately reload and remove the material from the site.

Only clean green material will be accepted at the drop off site.

West Marin equestrian facilities: West Marin Compost can supply your equestrian facility with an empty dumpster for used bedding and manure. Full dumpsters are hauled, and an empty dumpster provided, as needed. *Please call 662-9849 to set up your participation in the project and discuss fees.*

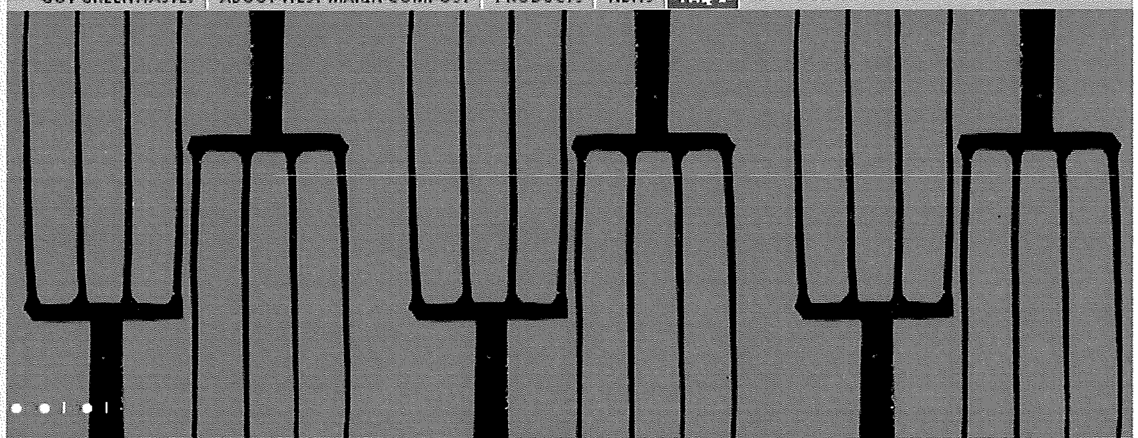
West Marin Compost is available as an organic soil amendment to local farms and the general public; for landscaping, restoration and erosion control throughout West Marin.

Compost will be available for retail purchase at the greenwaste drop off facility in Nicasio. Bulk compost can be purchased by calling 415 662 9849 for an appointment.

WEST MARIN
COMPOST

5575 Nicasio Valley Road *ph:* 415 662 9849

GOT GREENWASTE? | ABOUT WEST MARIN COMPOST | PRODUCTS | NEWS | FAQ'S



FAQ'S

What about noxious weeds?

Does west Marin Compost accept no×iousweeds, end what happens to weeds in the ¢omposting prooe~-?. ~.I~tMC; does accept almost all '~.~eed~." E×¢ept for Tim. In all seriousne~, most ~veeds and weed seeds are destroyed bythe high temperatures...

How is the compost made?

Dai~ manure separator solids are combined with appro×imately equal volumes of green and equestrian *materials,* formed into windro~ on the tempesting pad and watered as needed. Any runoff from the compost area flou'~ to the dales liquid...

How is compost better than liquid manure?

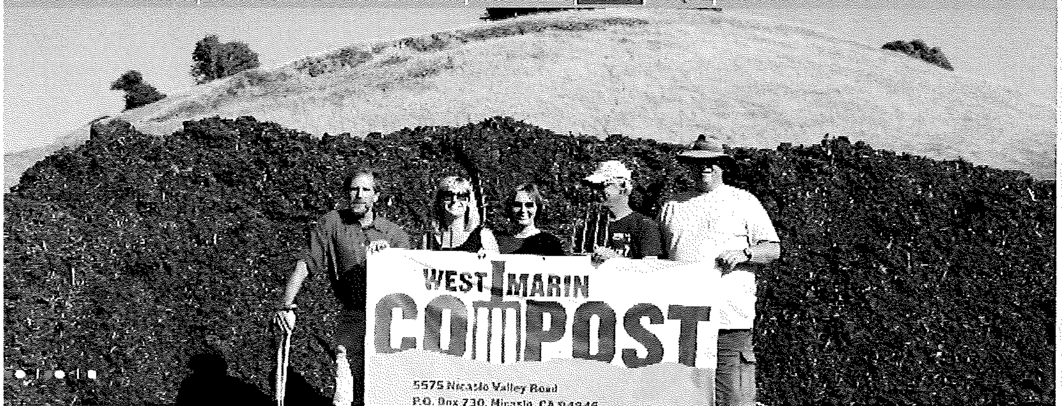
Beoause finished compost is a dr¢ material (typically le~ than 50% moi~ure at maturity, It is less costly to sp read than wet manure *(t~pi~ally75.g5%* water). Finished compost is odorle~, and the nutrients it contains are much le~ mobile under...

When is the drop off site open?

Drop off ~ite will be open from 12-q Monday to Friday" and 9-'| Saturday Clean green material only will accepted at the site

WEST MARIN COMPOST

5575 Nicasio Valley Road ph:415 662 9849



IIEWS

l~ompost at the l~ommons a huge hit for all gardeners

P|arin ~:ounty I=air

the tvt~dn County" Fair to see ~test M~dn's finest Compost -Ivbdn's Orlon -Madn's ONLY!!!

.~easonal Specials

West M~dn Prbcdsts *and Tree.Service* Profesaionals: Call West Ivbdn Compost for seasonal specials for cubic yard tipping fee rates atthe drop-off Site for all ground green m~tedal and chipped tree *matedal.* Call 4|5 662 gS~ for,

Now there's a responsible way" to deal with stable waste!

~ltest Ma~n Compost provides dumpster detivery and pick-up se~iceto *stables* ~nd equine facilities for equine t~aste and bedding materials. Call 415 862 g849 for set-up information and rates.

Donate your old Pitchforks!

Donate an old pitchfork and receive a discount on your tipping fee!' Old pitchforks u~ill be used in the creation of the netu ‾ elded gate at the drop.off site!! Call Loratta ~t 415 662.

Grand Opening of the West t~|arin Iiompost Drop-Off site

~t~est tutadn Compost is notu open to help you prepare your yard and 9z~en for ~inted] 5575 Nicasio Valley Road, Nioaslo (across from the Cour~y corporation yard) Open tC~nd~y through Fdday from ~2 - 4. and Saturday from 9 - 1. ~pping fee is.

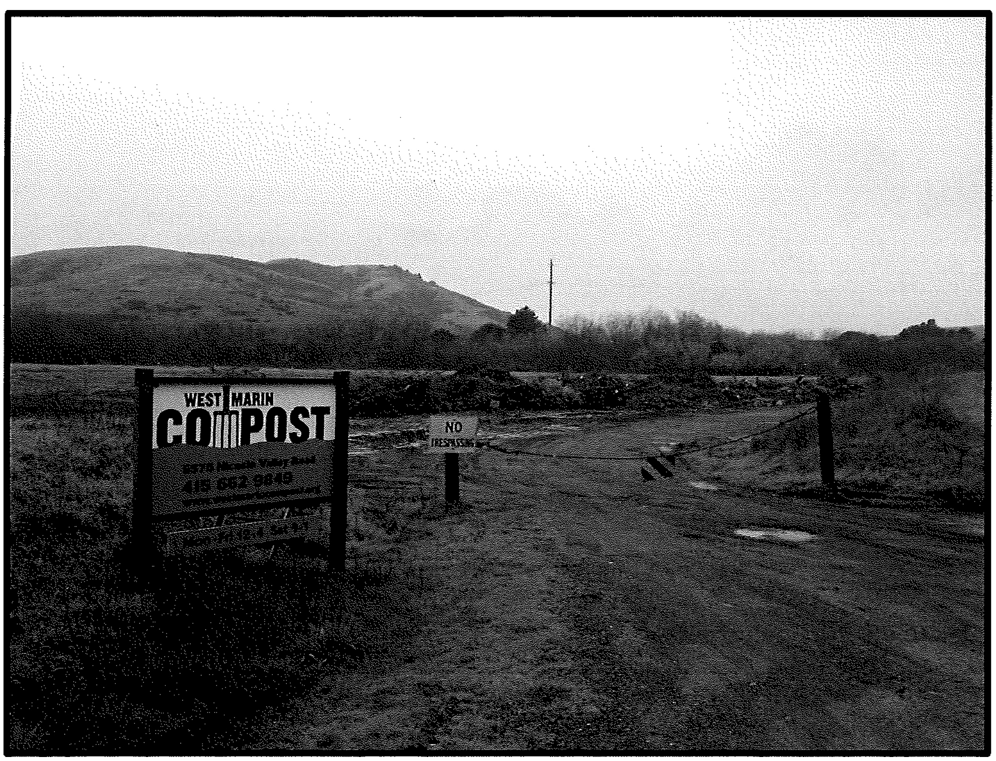
west matin compost project on KWI~IR

"Finally, a Place in ~'~'est t~'ladn to Drop Off Green Waste as a neu~ oompostin9 operation at Lafranchi Dairy in Nicasio opens aoon.""Kevin Lunny, ~uhose ~cmpany is in charge of the operation, tells Geon:je Clyde about the

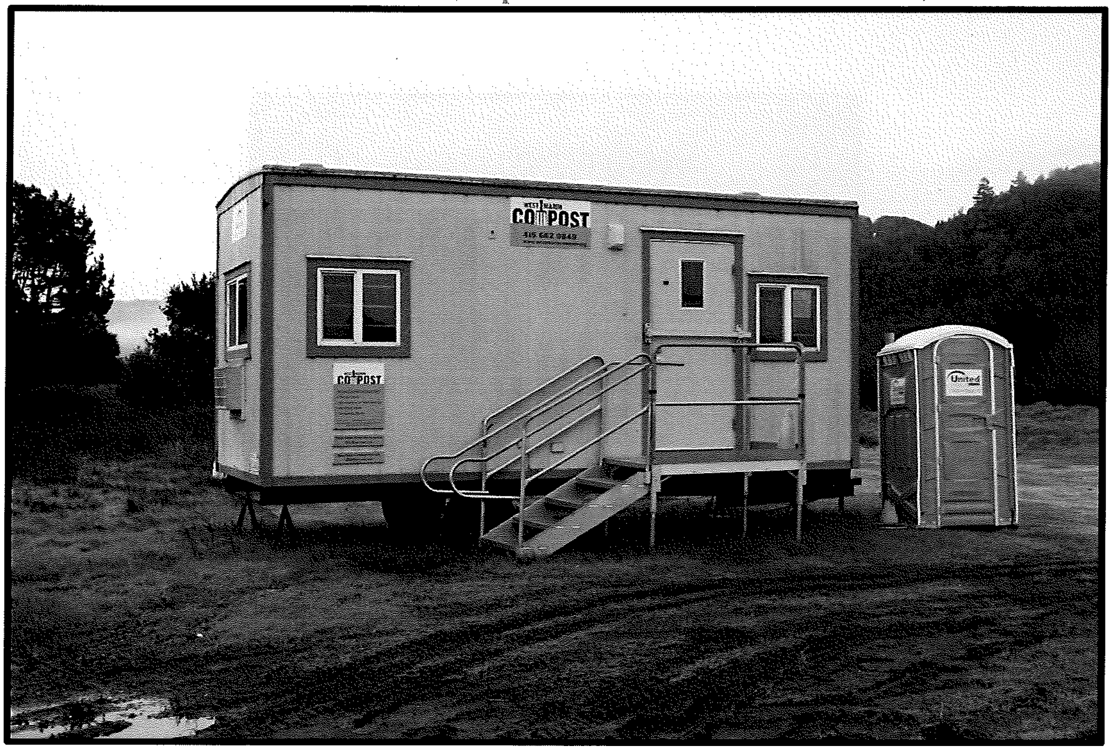
Appendix G

Photos: Dr’opooff Site, Compost Site, Compost Corr~mons Day

Green Waste Drop Off Site



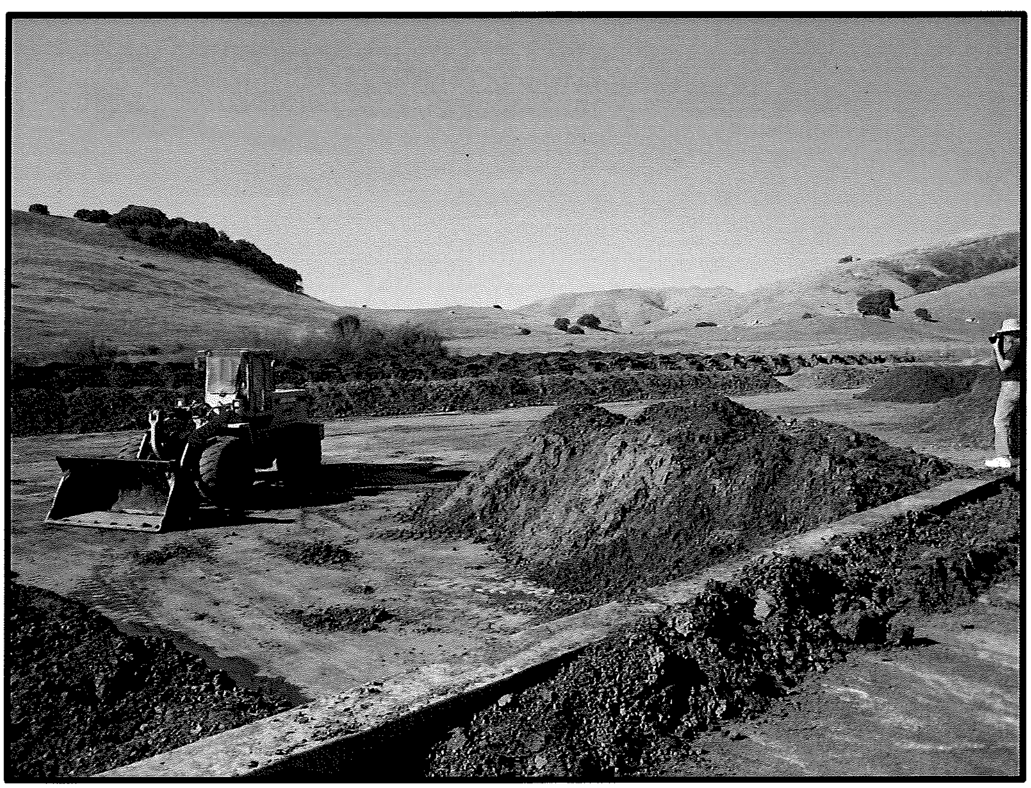
The entrance to the drop off site located in Nicasio, CA.



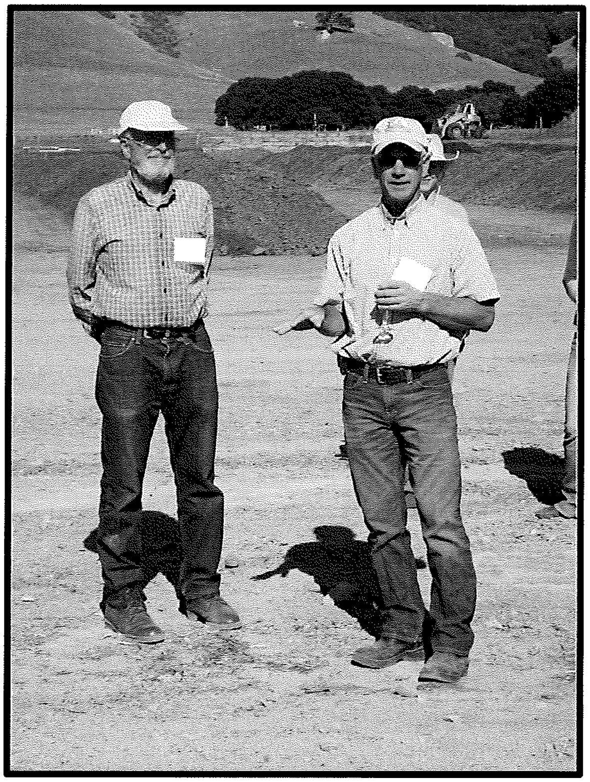
Portable office for the attendant. The operator plans to replace this with a permanent structure.

The extent of the drop offsite is *show~* here, The property is owned by Marir~ Munidpa~ Water District a~@ the County o~' Matin

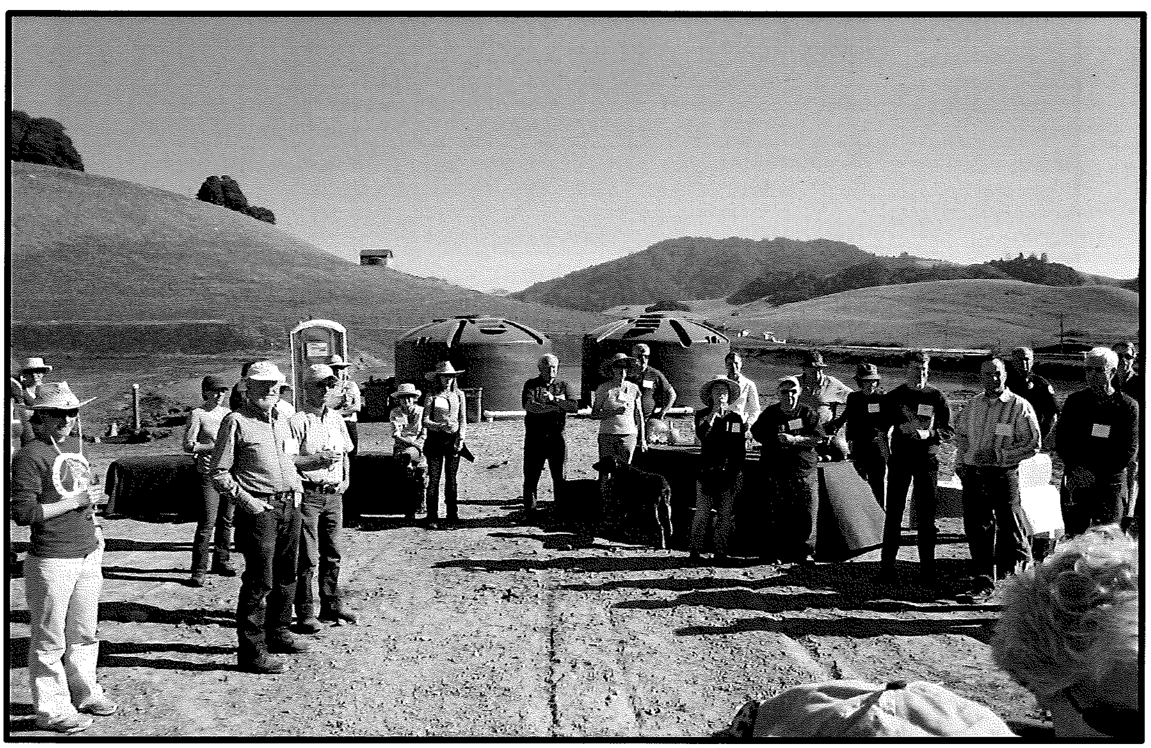
Compost W~ndrows



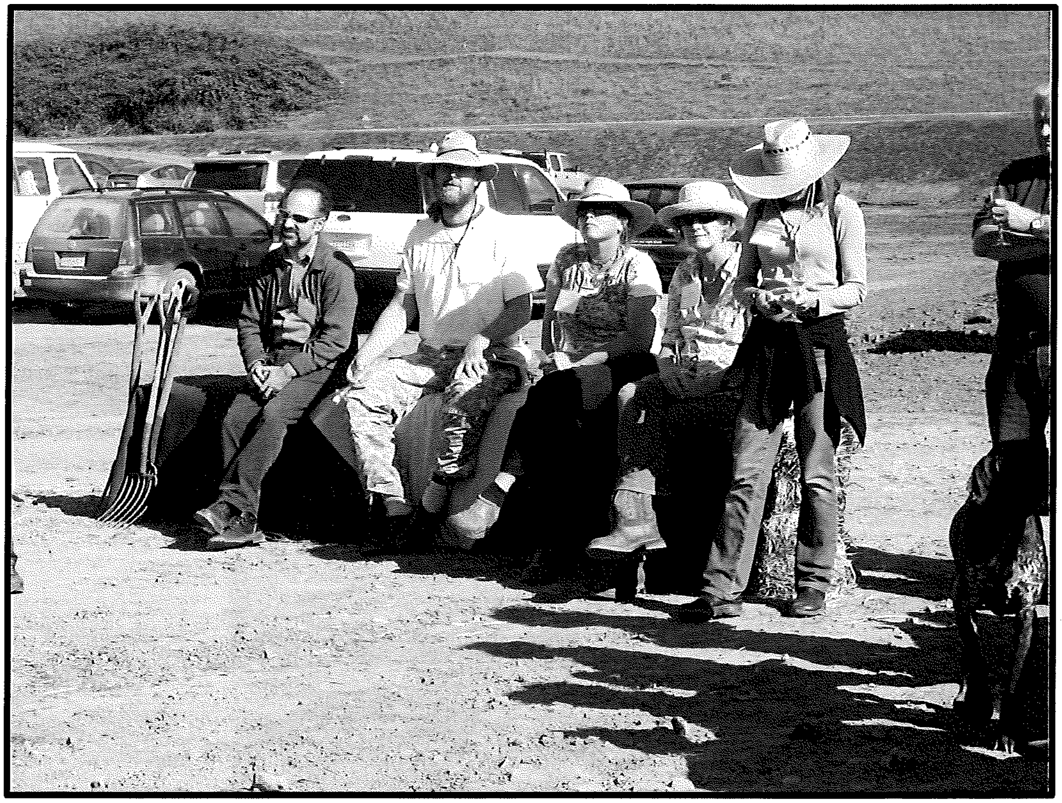
Staging Area

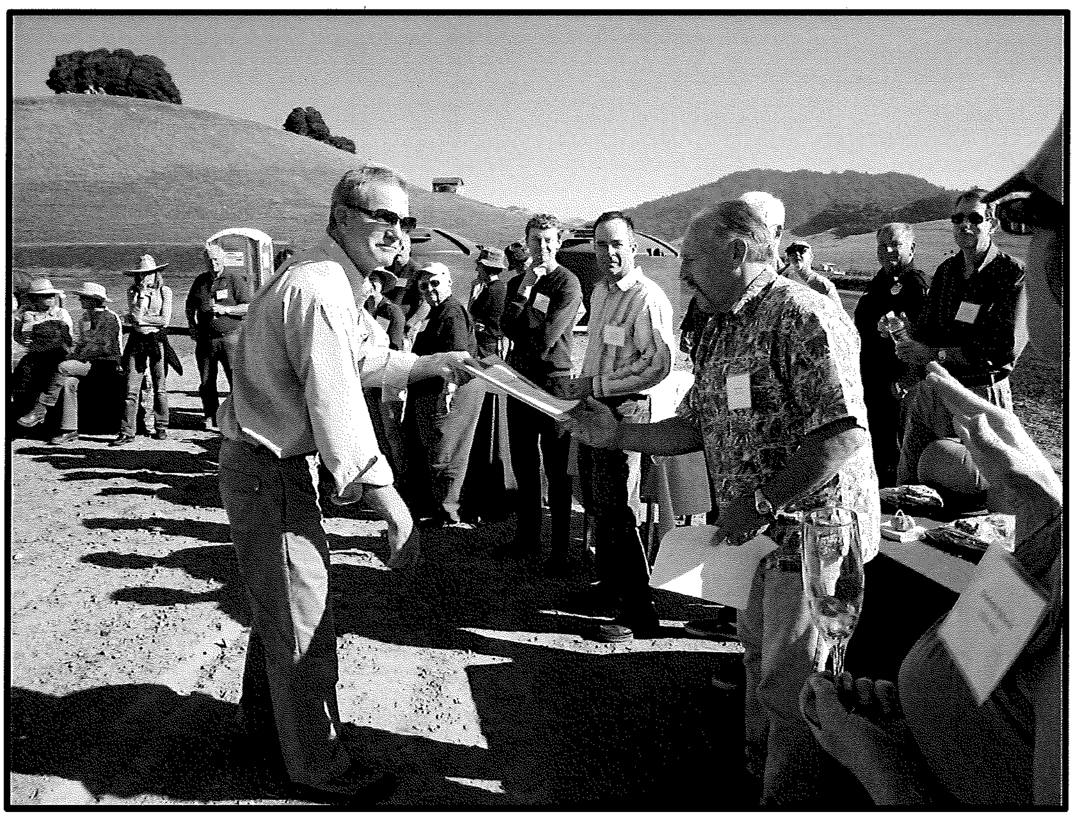


Compost Operator, Hev~n *Lmmy.*, describes t~e compos~ ~%~cilityo

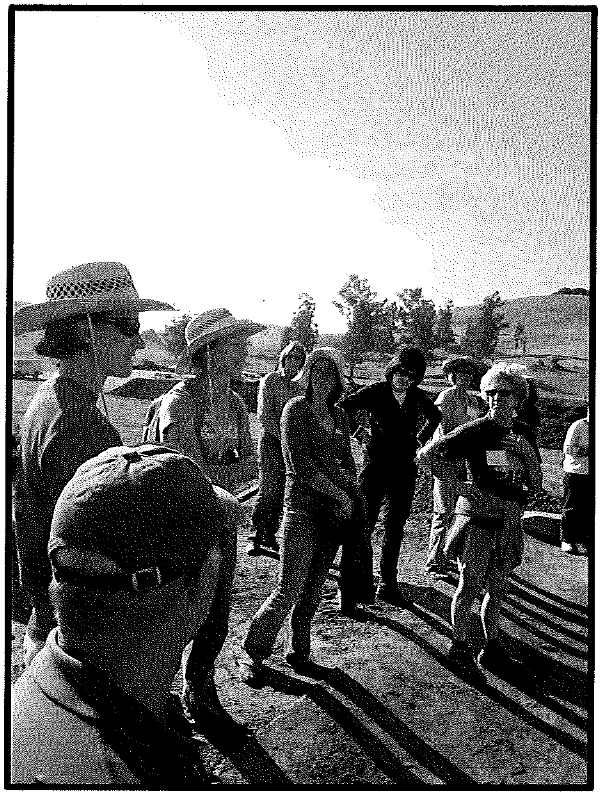


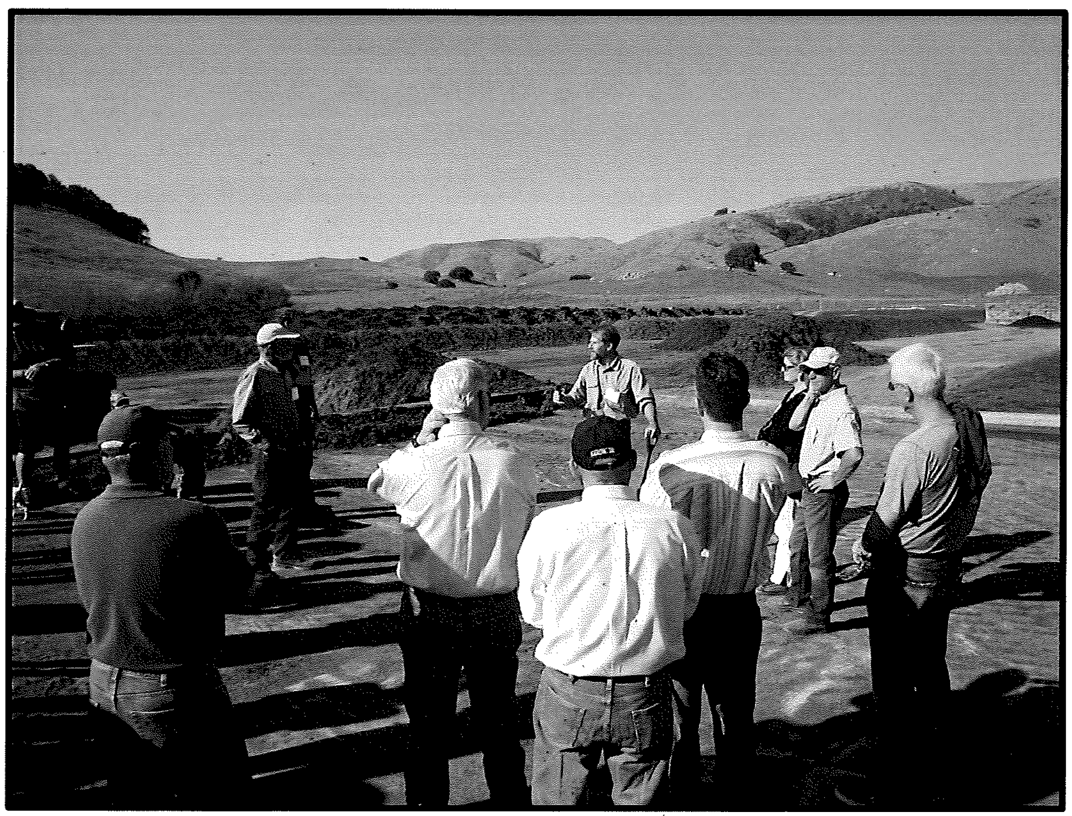
Attendees of the inaugural event include county administrators, press and equestrian facilities.



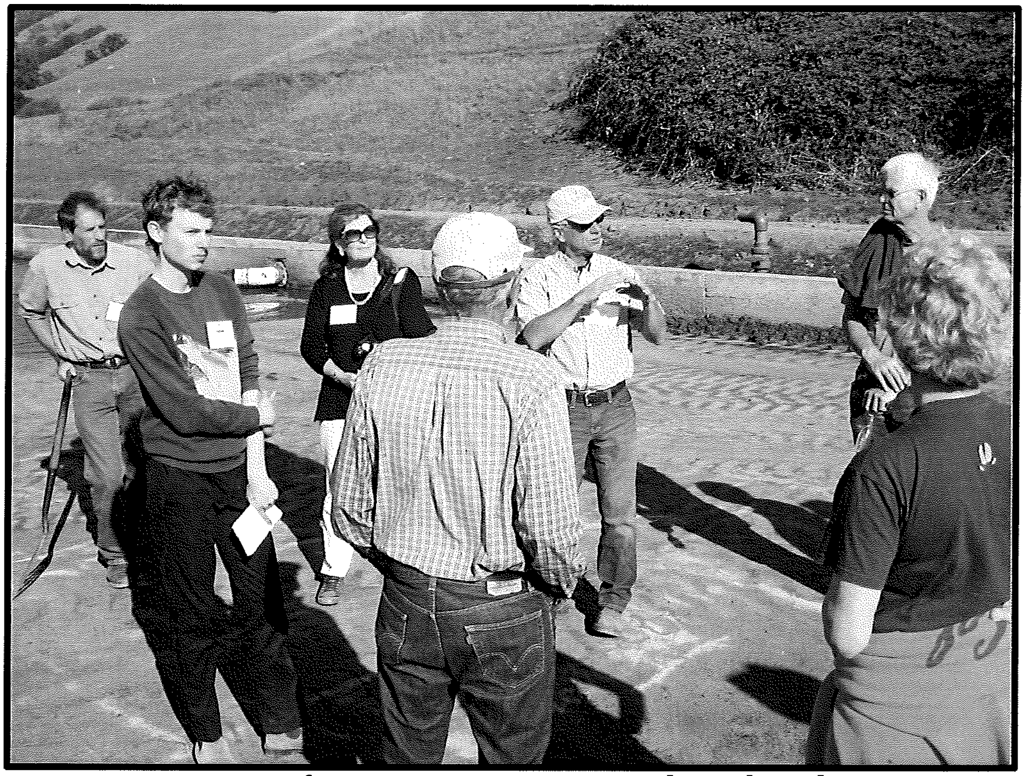


Marin County Supervisor Steve Kinsey presents Marin RCD President, Hank Corda with Assemblyman Jared Huffman's Certificate of Recognition.





Jeff Creque of West Marin Compost Coalition describes the biochemical composting process.

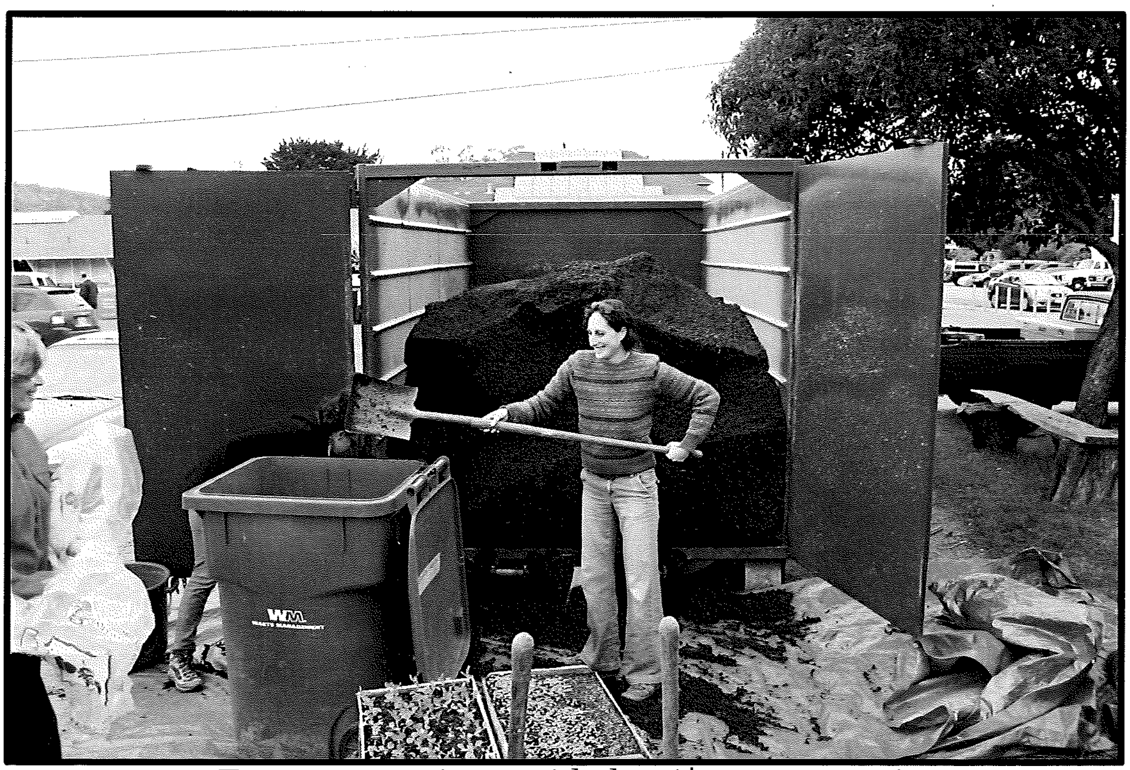


Kevin L~m~y of West Mari~ Compost describes tl~e gravity ma+~°e *sepa~'ator* syster~ for the dairy,

Project part~;~ers!!

Compost Day at the Commons - March 2012

Compost talk is being provided by West Marin Compost Coalition.



Free compostis provided to the commur~ity,