Chapter 4. Land Productivity

Introduction

This chapter describes the potential impacts of biosolids applications on land productivity, including agricultural lands, forest lands, reclamation sites, and horticultural areas. Land productivity is the amount of biomass a soil and the associated climate can produce on a sustainable, long-term basis. For agricultural crops, land productivity is typically measured as the annual yield per acre (e.g., in bushels, pounds, or tons per acre). For grazing lands, productivity is normally measured in pounds or tons of forage per acre, but sometimes as the number of grazing animals per acre per month (animal-unit months) the land can support without deteriorating.

Inherent or native land productivity usually assumes normal agricultural management operations, not unusual operations such as installation of a tile drainage system, land leveling, or deep ripping of hardpans. These measures can greatly improve the productivity of certain marginal farmlands. Application of fertilizers or soil amendments can increase crop yields in the short term by compensating for deficiencies in soil nutrient status and taking advantage of the soil's ability to store added nutrients and transform them to bioavailable forms. Normal fertilization and soil amendment practices generally are not considered to have an effect on long-term land productivity when fertilizer and organic amendments contain low levels of heavy metal contaminants.

Land productivity can also be decreased or even eliminated by certain agricultural and grazing activities, excessive erosion of fertile topsoil layers, gullying, salt accumulation, and water table problems. Accumulation of phytotoxic compounds through incorporation of fertilizer or organic amendments containing heavy metal contaminants into the soil is another possible means by which land productivity becomes degraded (Witter 1996). Normally, application of fertilizers and soil amendments, including biosolids, that are not acutely toxic to plants would take long periods of time to accumulate in the soil in damaging quantities.

Environmental Setting

As discussed in the setting section of Chapter 3, "Soils, Hydrology, and Water Quality", both the physical and chemical conditions of the soil determine the inherent productivity of a specific parcel of land. The chemical conditions of a soil include the level of native or inherent plant-available nutrients; the nutrient storage and supplying capacity of the soil; and the presence of phytotoxic substances such as heavy metals, boron, or soluble salts. Although adding fertilizers to land can improve plant yields, inherent productivity usually does not change because most fertilization effects are short lived. Vegetation management systems, plant types, other land management practices, and seasonal weather factors dictate the actual yield of land over the long term.

Soils also contain macro- and micro-organisms (e.g., small mammals, earthworms, bacteria) that have important functions in carrying out the biochemical processes and transformations that convert chemical compounds to bioavailable and mobile forms that can be taken up by plant roots. Important soil micro-organisms and beneficial soil insects may have different sensitivities to the presence of toxic compounds in soils than do plants, which can also vary greatly in their sensitivities to differing heavy metal concentrations in soils (McGrath et al. 1994, 1995; Cornell Waste Management Institute 1997).

Impacts and Mitigation Measures

Thresholds of Significance

The adoption of the proposed GO would have a significant impact on the environment if it would:

- cause substantial accelerated erosion and sedimentation;
- adversely and substantially affect soil productivity, yield, or quality; or
- cause a change in the land classification of a given area.

Impacts of Agricultural Use

Impact: Changes in Physical Soil Properties and Resulting Effects on Productivity

Application of biosolids to soil would increase the organic matter and organic carbon content of the soil; however, most of the organic matter contributed by biosolids is rapidly mineralized. Artiola and Pepper (1992) reported that 65% of the organic matter contributed by biosolids was mineralized within the first year. Resistant residual organic matter increased by 0.013% per year in that study. Aitken (1995) noted a 0.9% increase in organic carbon content over an 8-year biosolids application period. Over time, however, even resistant organic carbon content would decrease once biosolids applications have ceased. For example, Hyun et al. (1998) noted a 40% decrease in organic carbon content of the soil over a 10-year period after biosolids land applications ended.

Increased organic carbon content in soil from biosolids applications would result in the following beneficial effects on physical properties of the soil:

- increased water-holding capacity, particularly in soils already low in organic matter and in medium- to coarse-textured soils (a study conducted by Epstein [1975] found that applications of biosolids increased soil water retention) and

- reduced bulk density, particularly in fine-textured soils, because biosolids have a lower bulk density than most soils (Darmody et al. 1983).

Application of biosolids may temporarily impede soil infiltration and permeability by plugging soil pores. However, this temporary effect may be offset by the beneficial effect of decreased bulk density (National Academy of Sciences 1996). Soils with lower bulk density tend to be more permeable and have a higher infiltration capacity than soils with high bulk density.

A long-term, well-managed program of biosolids application would normally be expected to improve soil productivity, both over the short term and over the long term. In unusual circumstances (e.g., a clayey soil worked when too wet during biosolids incorporation), physical conditions of the soil could be adversely affected and yields could suffer. This is likely to be a short-term or transitory effect that subsequent proper soil tillage and management could correct. Because the potential for these adverse impacts on soil physical conditions is low, reversible, and manageable given the experience and capabilities of California farmers and ranchers, this impact is considered less than significant.

Mitigation Measures: No mitigation is required.

Impact: Changes in Soil Fertility and Salinity and Resulting Effects on Productivity

Application of biosolids would increase the levels of nutrients and salts in the soil. Elements that would be added to the soil include nitrogen, phosphorus, potassium, calcium, magnesium, sodium, and chloride. All of these elements except phosphorus are water soluble and can be leached from upper soil layers. Phosphorus commonly is retained in the upper soil layers.

Soil pH would decrease as a result of the application of biosolids (Harrison et al. 1994). The pH decrease would result from the mineralization and nitrification of biosolids organic matter (Harrison et al. 1994, Emmerlich et al. 1982).

The soils' cation exchange capacity (CEC) would increase. This would be especially beneficial to coarse-textured soils with low organic-matter content. Agronomically appropriate applications of biosolids to farmlands generally have positive effects on plant growth and yield through the addition of plant nutrients (National Research Council 1996). Most biosolids contain both fast-release and slow-release forms of plant nutrients, as well as complex and stable organic fractions that improve the soil's ability to store nutrients. Therefore, the soil-fertility and plant-nutrient effects of a long-term, well-managed biosolids application program would generally be beneficial to agricultural soils and land productivity.

Several potential problems could arise, however, from implementation of the GO as currently proposed. For example, the proposed GO requires that land applications be based on agronomic rates for nitrogen (primarily to protect water quality) but does not provide direction or guidelines for management of other essential plant nutrients, such as phosphorus. The proposed GO has no requirement to balance biosolids applications with fertilizer additions of other plant nutrients. The GO also does not require that appliers or land managers develop a long-term view of biosolids as part of an overall soil-fertility and nutrient-management program. (Under similar circumstances, RWQCBs often require land-intensive livestock and dairy operators to develop overall nutrient management plans to control potential water quality impacts from their animal waste land-spreading operations.)

Under unusual circumstances, plant nutrition and soil fertility could be adversely affected by biosolids applications. For example, productivity could be adversely affected if biosolids applications create nutrient imbalances.

Similar to poor fertilization practices, such atypical problems could cause short-term to intermediate-term reductions in yields. In severe cases (e.g., long-term additions of biosolids with high carbon-nitrogen ratios or biosolids with lime-stabilized, low-bioavailable phosphorus), land productivity could be reduced, but this effect would be

reversible once recognized. Recognition of complex fertility problems may not be within the experience or management capability of many California farmers, but assistance with potential problems would be available from the University of California (UC) Cooperative Extension or private agricultural and soil testing/agronomic consulting firms.

Although adverse crop productivity impacts from changes in soil nutrient and salt levels are unlikely to occur under the proposed GO, this impact is considered potentially significant. The following mitigation measure should be implemented to reduce this potential impact to a less-than-significant level.

Mitigation Measure 4-1: Provide Soil- and Site-Screening Information with the Pre-Application Report. The GO Pre-Application Report should be revised to require that WDR applicants provide sufficient soil and site information such that RWQCB staff can determine whether soils would be degraded and/or land productivity would be reduced as a result of biosolids application. In particular, providing the information is intended to ensure that 1) essential soil nutrients other than nitrogen are applied so that significant nutrient imbalances do not occur, 2) metals-related phytotoxicity does not occur, 3) increases in salinity do not occur to the point that the yields of the crop(s) typically grown at the site is appreciably reduced, and 4) appreciable accelerated soil erosion does not occur.

The Pre-Application Report already requires sufficient information with which effects of potential nutrient imbalances, metals phytotoxicity, and excessive salinity can be analyzed. This information should be used by the applicant, a qualified soil scientist, or a qualified agronomist to evaluate the above potential effects on producitivity. The GO Pre-Application Report also should be amended to include the erosion hazard (derived from USDA soil survey reports[1]) of the proposed application site.

Additionally, the following table should be added to the GO Pre-Application Report. Applicants or qualified soil scientists or agronomists should use the table to further determine whether soils could be degraded or land productivity reduced.

[1] Where a soils survey report is not available for a proposed application site, the applicant should have a qualified soil scientist determine the erosion hazard (using NRCS guidelines), unless the slope of the site is 3% or less. Sites with slopes of 3% or less will be considered to have a slight erosion hazard.

Limitations to Land Application

Parameter	Slight	Moderate	Severe
Cation exchange capacity[a] (average milliequivalents per 100 g, 0-20 inches depth	>15	10-15	<10
pH[b] (average 0-20 inches depth)	>6.5	5.0 to 6.5	<5.0
Erosion hazard rating[c]	None to slight	Moderate	High to severe

[a] Cation exchange capacity limits based on professional judgment.
[b] pH limits based on U.S. Department of Agriculture (1993).
[c] Erosion hazard limits based on professional judgment.

Sampling of biosolids and soils should follow the procedures and protocols currently approved by the EPA/DHS.

Provided that the applicant, a soil scientist, or agronomist has provided written confirmation to the RWQCB that soils would not be degraded and/or land productivity would not be reduced as a result of nutrient imbalances, metals-related phytotoxicity, or adverse salinity effects, biosolids may be applied on any site having a “slight” limitation as defined in the table. At sites having a “moderate” limitation, biosolids may be applied only where the crop is not particularly sensitive to metals and nutrient imbalances. Sites having a “severe” limitation are excluded from eligibility under the GO and a site-specific waste discharge investigation and planning study should be conducted by a qualified soil scientist or agronomist to provide, in writing to the RWQCB, written confirmation that biosolids application would not cause soil degradation and would not reduce crop yield.

The GO and the Pre-Application Report also should be amended to specify an absolute upper slope limit of 20% at sites in which the biosolids would not be immediately covered by sod or a sufficient mulch cover to control erosion.

Impact: Changes in Trace Elements and Heavy Metal Plant Toxicity in Soils and Resulting Effects on Productivity

Trace elements and heavy metals present in biosolids in elevated amounts and incorporated in agricultural soils can, under certain unique circumstances, have direct adverse effects on soil productivity by reducing crop yields and affecting crop quality and appearance (Schmidt 1997). Most California soils have a high capacity to bind up additional heavy metals, making them biologically unavailable. However, because California soils vary widely in their ability to attenuate or bind up heavy metals, and

crops also vary widely in their sensitivity to bioavailable heavy metals in the soil-water solution, applications of biosolids at high rates onto certain combinations of soils and crops over the long term could result in potentially significant phytotoxicity problems. Leafy vegetables (e.g., lettuce, spinach) are often extremely sensitive to heavy metal phytotoxicity (Channey and Hundemann in U.S. Environmental Protection Agency 1992). These crops can be grown on sandy soils with low heavy metal-attenuating capabilities, such as some soils in the Salinas Valley, Central Valley, and Imperial Valley.

Phytotoxicity problems are normally expected to emerge slowly over time and, once recognized, to be managed accordingly. Because for most heavy metals bioavailability is pH-dependent, the most common management action would be to add lime to the acidic soils to bind or tie up the heavy metals in unavailable forms. Under this assumption, biosolids management relies almost entirely on the abilities of the farmer or rancher to recognize emerging phytotoxicity problems, correlate the problem with bioavailable heavy metals in the added sludge, and know that the management solution is to add lime to the soil and eliminate further biosolids applications. Some heavy metals, however, are not more bioavailable under acidic soil conditions, and self-management of problem soils would require that farmers also have a good general knowledge of soil chemistry and a working knowledge of how to diagnose and manage a range of phytotoxic heavy metals problems.

The degree of impact on crop productivity could range from negligible, with only a slight decrease in yield, to significant phytotoxic effects, with yield reductions of 10%-40% or more for certain highly sensitive crops (such as green leafy vegetables) and in certain soils with low native heavy metals-attenuation capabilities (such as the valley sandy soils mentioned above); this level of reduction could result from biosolids application levels that might be permitted under the federal Part 503 regulations and the proposed GO (Cornell Waste Management Institute 1997). The degree of impact is expected to correlate well with the heavy metal in question, the amount of bioavailable heavy metal in the biosolids, total cumulative loading amounts, the chemistry of the soil, soil management actions, and the crop. Potential impacts would likely occur only after years of biosolids heavy metals loading under the existing annual and total allowable loading limits. However, in some cases, farmlands could reach their maximum allowable heavy metals loading limits (at which yield reductions would begin to be experienced) after 10 years of annual applications at the high end of the annual loading limits (California Farm Bureau 1998). Only certain soils (e.g., acidic and poorly managed) would be subject to yield reductions. Synergistic toxicity effects between heavy metals may also occur, making impacts additive in some cases.

The GO relies on the federal Part 503 regulations to minimize or control potential heavy metal-related impacts on agricultural soils and land productivity; it adds several new restrictions to reflect California's soil and crop conditions.

Some experts question the conclusions of the analysis conducted for the Part 503 regulations concerning the potential long-term effects on soil productivity from the presence of heavy metals in biosolids and their accumulation in soils after years of application at allowable rates. The allowable cumulative loading limits established in the Part 503 regulations are based on nationwide average soil conditions and do not conservatively reflect potential problems that could be encountered with some soil/crop combinations. Because it is difficult to effectively remove heavy metals from soil, permanent land degradation could result.

Considerable disagreement exists within the scientific and farming communities on this issue. Some of the controversy surrounds the fact that thorough research and long-term field trial information is not available on crop effects over the full range of soils and crop conditions where biosolids could be applied, making it difficult to accurately characterize the consequences of long-term biosolids heavy metals additions, particularly for atypical or unusual soil chemistry conditions, for sites that are managed poorly (in terms of tracking application rates, spreading sludge, and managing pH), or for specialty crops for which toxicity data do not exist.

The EPA analysis has been criticized for using average soil conditions and nonconservative assumptions when data were missing to complete the risk assessments for potential crop effects under the Part 503 regulations. This is a concern to some parties because California supports a wide variety of soils and crops that could be outside the range of conditions assumed by the EPA's risk assessment models.

The Part 503 regulations regarding heavy metals have been criticized for the following reasons:

- A relatively narrow range of soils and crops were considered by the EPA in evaluating potential impacts on crop yields and productivity. This range did not adequately reflect the range of soil and crop conditions found in California. Crops can vary widely in their sensitivity to heavy metals, and soils vary widely in their heavy metals attenuation ability.

- The Part 503 regulatory approach relies on projections of possible future quantities and types of heavy metals in the soil and amounts that may be phytotoxic under normal soil conditions and to typical crops, based on mathematical calculations of heavy metals in biosolids and estimates of loading. Estimation of average biosolids concentrations of total heavy metal levels, available heavy metals in soils after years of application, and biosolids application rates cannot in themselves be precise.

- There is no requirement to characterize soil conditions at a proposed biosolids application site for fertility, erosion hazard, or heavy metal-attenuating capability; track actual bioavailable heavy metals concentrations in the soils; or manage the soils to reduce phytotoxicity problems.

Properties and characteristics of soils that make them potentially subject to heavy metals toxicity problems include low pH, high sand content, low CEC, and low organic-matter content. The NRCS has recognized more than 1,700 soil series in California. An analysis of the NRCS soil database indicates that only a small proportion (perhaps 10%-15%) of California soil series have conditions that would lend themselves to potential problems under poor management and would therefore make them potentially susceptible to heavy metal bioavailability problems. However, biosolids have been land applied to California soils for more than 20 years in some areas and no problems related to heavy metals have been documented. Additionally, the proposed GO requires that cumulative loading limits for heavy metals at land application sites include the natural levels of heavy metals in the soil before application of biosolids.

Based on the above analysis, significant impacts relating to land productivity and heavy metals accumulation on agricultural soils could occur under the proposed GO for some combinations of California soils and crops and at poorly managed sites, but this circumstance would most likely be rare. The probability that the impact would not be widespread, however, does not reduce the potential for adverse effects in specific areas of California caused by the buildup over time of the bioavailable forms of heavy metals at phytotoxic levels in a small number of agricultural soil-crop combinations. Therefore, this impact is considered potentially significant.

Mitigation Measure 4-1 should be implemented to reduce this impact to a less-than-significant level.

Impact: Changes in Amount of Synthetic Organic Compounds in Soils and Resulting Effects on Agricultural Productivity

No synthetic organic compounds (SOCs) are currently regulated under the Part 503 regulations or the proposed GO, although the proposed GO and existing state regulations require routine testing of biosolids for semi-volatile organic compounds, aldrin, dieldren, and polychlorinated biphenyls (PCBs). Testing for other organic compounds is conducted at the discretion of the producer and the RWQCB. Testing decisions are based, in part, on the characteristic industries within the treatment plant service area. No annual or cumulative loading limits have been established for SOCs; concentrations in biosolids are limited by general hazardous waste requirements contained in Title 22 of the California Code of Regulations. Sludge standards for PCBs, dioxins, furans, and perhaps polycyclic aromatic hydrocarbons (PAHs) and persistent pesticides are proposed for future development by the EPA (Cornell Waste Management Institute 1997). When

adopted, these standards would automatically become a mandatory part of the state's biosolids management program.

Except in highly unusual situations, the presence of elevated levels of SOCs in soils as a result of biosolids application would not have a direct effect on soil productivity or crop yield because SOCs are typically not taken up by plants in measurable or phytotoxic quantities at concentrations normally found in biosolids. Human health or food quality effects, however, could result from plant uptake of low levels of SOCs that are not phytotoxic. This issue is addressed in Chapter 5, "Public Health". Direct impacts on agricultural soil productivity resulting from the presence of SOCs in biosolids are not expected, although impacts on the health of grazing animals could result from the use of biosolids high in SOCs if animals ingest soil directly during grazing.

Within Title 22 limits, high levels of SOCs originating from POTWs with industrial sources are still permitted in biosolids, adversely affecting populations of beneficial soil microorganisms and insects that may be more sensitive to these toxins than vascular plants (McGrath et al. 1994, 1995). Microorganisms assist plants in breaking down organic matter and using nutrients in various elemental transformations, such as the nitrogen cycle, and in direct uptake of plant nutrients through mycorrhizal bacteria. Although in some situations populations of soil microorganisms may be harmed by SOCs in soils, not enough information is available to conclude that biosolids with high SOCs would substantially damage soil productivity, particularly over the long term. The field of bioremediation of hazardous materials present in soils relies on the resiliency of soil microbial populations to eventually biodegrade SOCs and recover. The Title 22 regulations on hazardous waste establish upper limits for allowable levels of SOCs in materials that can be incorporated in soils. Many of these compounds would be expected to biodegrade over time when put in a soil environment with a good food source, such as the organic matter in the biosolids.

This potential impact is considered less than significant. (Note: An Oak Ridge National Laboratory [ORNL] study of biosolids SOC effects on soil microfauna is in progress. The findings of that study could alter the conclusions of this analysis. Any proposed or final changes in the Part 503 regulations that result from the findings of the ORNL study would be reflected in required updates to the state's GO.)

Mitigation Measures: No mitigation is required.

Impact: Changes in Grazing-Land Productivity

Grazing animals typically ingest some soil along with forage plants. Depending on variables such as the kind of animal, time of year, condition of pasture, method of biosolids application, and amount of time between application and use of fields by livestock, grazing animals could ingest 1%-30% of their total intake in soil matter (Fries

1996 as cited in Cornell Waste Management Institute 1997); therefore, compounds present in biosolids could be directly ingested by grazing animals in a variety of ways: from forage plants that have taken up compounds through their roots, from dust on the plants, and from the soil-biosolids mixture. (Concerns over potential human health risks associated with consuming meat from animals raised on biosolids-treated fields are addressed in Chapter 5, "Public Health".)

Agriculture-related impacts could result from two activities associated with long-term, excessive land applications of biosolids containing elevated levels of heavy metals or SOCs and from the subsequent ingestion by grazing animals of soils contaminated with heavy metals or SOCs:

- Nutritional deficiency or toxicity problems could become severe, acute, and lethal, causing mortality of animals and the corresponding devaluation of pastureland as unsuitable for grazing.

- Nutrition problems could occur that result in sublethal effects, including low animal weight, low reproductive success, or low milk yields (for dairy animals). Some of these problems could remain undetected.

Based on the present knowledge of typical California agricultural and rangeland soils and the common range of regulated heavy metals in biosolids, it appears unlikely that regulated heavy metals would accumulate in pastures to levels or at bioavailable concentrations that could substantially affect forage productivity or animal health. Such problems, should they occur from long-term heavy metal buildup, are likely to be relatively rare. Conversely, biosolids applied at appropriate rates should usually result in an improvement of pastureland productivity.

In spite of the proposed GO's provisions regarding regulation of heavy metals, there are specific conditions where extra care should be taken. Some California soils are naturally high in selenium (e.g., the soils of portions of western San Joaquin Valley), increasing the risk of selenium toxicity from combined native and biosolids sources. Both molybdenum and selenium can be present in soil at concentrations that are not detrimental to plant growth, yet be taken up by forage plants and result in concentrations in plants that are toxic to grazing animals (Cornell Waste Management Institute 1997). Unlike many other heavy metals, these elements can also be bioavailable at neutral to slightly alkaline soil pH levels.

The Cornell Waste Management Institute (1997) has concluded that the possibility of grazing animal toxicity problems occurring under the current Part 503 regulations (and therefore under the proposed GO) is real. The institute's research leads to the conclusion that the present database on soils, plant uptake, and biosolids composition is inadequate to assess the full magnitude of this potential problem.

Although the combination of circumstances that could lead to toxicity in grazing animals in California is probably only remotely possible, this impact is considered potentially significant. In addition to Mitigation Measure 4-1, the following mitigation measure should be implemented to reduce this impact to a less-than-significant level.

Mitigation Measure 4-2: Extend Grazing Restriction Period to Allow for SOC Biodegradation. For grazing sites where biosolids applications are proposed, the GO should be revised to require that grazing of animals be deferred for at least 90 days after land application. The GO should also be revised to prohibit grazing animals from using a site for at least 60 days after application of biosolids. Average daytime daily temperatures must exceed 50EF for 60 cumulative days. These measures will promote maximum biodegradation of SOCs and pathogens before grazing animals are exposed to the soil.

Impact: Increases in Soil Erosion Rates and Resulting Effects on Production

Soil erosion rates can accelerate when cultivated lands are disturbed by tilling operations, such as for biosolids incorporation, and the soil surface is left barren and unprotected from winter rains. This could occur at some erodible sites if biosolids are incorporated in the early fall and early, unseasonable rains occur before a protective cover crop becomes well established.

Severe, long-term soil erosion can affect agricultural productivity through loss of fertile and productive topsoil layers. In extreme cases, gullying can leave an area untillable. Most soil erosion on farmland is easily controlled through development and implementation of conservation tillage methods, proper water management, and use of cover crops.

The greatest hazard of erosion occurs on sloping lands. The proposed GO addresses this hazard by requiring that an erosion control plan be prepared by a qualified professional on slopes greater than 10%. No upper slope gradient limits are imposed. Some sandy California soils, however, are relatively susceptible to erosion on slopes as shallow as 5%-7% when tilled and left unprotected. Although incorporation of biosolids on erodible soils with slopes gentler than 10% would probably be rare in most areas of California, the sandy Dinuba and Delhi series soils (for example), which occur along the eastern San Joaquin Valley, are susceptible to erosion on slopes gentler than 10%. Incorporating biosolids on these or similar soils could result in locally significant impacts on soil resources.

Additionally, early season erosion may be difficult to control on steep land-application sites, even when an erosion control plan has been developed and implemented. Therefore, potentially significant accelerated erosion could occur on slopes of 20%-30% (i.e., the upper slope limit for using the wheeled farm machinery typically used to spread

biosolids). The impact of erosion on farmland productivity is considered potentially significant. Mitigation Measure 4-1 should be implemented to reduce these impacts to a less-than-significant level.

Impact: Changes in Farmland Classification

Agricultural lands are often classified by government agencies (such as the NRCS) according to their ability to produce crops, most often using a system based on a specific set of soil and site characteristics that influence or limit the ability of farmland to be cultivated or managed. Although farmland productivity issues have been addressed previously in this chapter for other impacts of the proposed GO, productivity effects that result in changes in the classification of certain farmlands could adversely affect farmers and agencies administering certain agricultural programs. For example, some U.S. Department of Agriculture programs (e.g., the Conservation Reserve Program) and state programs (e.g., the Williamson Act) use farmland classifications, such as prime farmland designations, to determine participation criteria and local funding levels for their programs.

Agricultural lands are classified using a variety of systems. Farmland classification systems, such as the U.S. Department of Agriculture's Land Capability Classification system, the University of California's Storie Index, and the California Department of Conservation's Important Farmland Mapping and Monitoring Program, consider such factors as salinity, fertility, and toxicity.

Farmland classification systems recognize human impacts on land by considering land-improvement practices such as land leveling, drainage, and irrigation in determining farmland status. In severe cases, accelerated erosion can downgrade a land classification level.

Application of biosolids could affect the classification of specific farmlands in various ways, although changes in classification would probably be unusual. For example, over the long term, the incorporation of biosolids could improve productivity and bring marginal farmland into a higher land classification status. Conversely, heavy metals buildup in soils as a result of biosolids application could reduce a site's productivity and classification if it approaches phytotoxic levels. Similarly, severe cases of erosion caused by biosolids application on erodible soils or steep slopes could decrease the productivity of farmland and its farmland classification.

Although changes in farmland classification could occur under the proposed GO, this impact is considered less than significant because changes would most likely be rare and would not result in environmental impacts over and above those already evaluated in this chapter. Additionally, implementation of the mitigation measures recommended in this

chapter would reduce effects that are likely to lead to changes in farmland classification by ensuring that toxicity and adverse soil fertility problems would not occur.

Mitigation Measures: No mitigation is required.

Impact: Effect on Agricultural Lands Caused by Public Concerns about Crop Contamination from Biosolids Applications

Although accumulation of heavy metals and SOCs in soils as a result of biosolids application may affect crop yields only marginally, the productive value of farmlands may be reduced if consumers perceive that public health risks are associated with consuming crops produced on lands treated with biosolids. For farmlands on which biosolids have been applied and that have subsequently been poorly managed, farm operators could lose access to certain markets (e.g., the organic produce market, the food processing market) if crop contamination is perceived as a possibility by consumers or wholesale produce buyers.

Depending on public understanding and confidence in a biosolids regulatory program, the market exclusion could extend to most fresh produce originating from areas where biosolids have been extensively, but not comprehensively, applied. The problem could be compounded if no regulatory requirement exists to track and publicly identify lands on which biosolids have been applied (including EQ biosolids) because produce buyers could suspect that biosolids were applied to all lands near biosolids application sites.

This crop contamination concern, whether real or perceived, could nevertheless have adverse effects on the ability of farm operators to effectively market their produce, thereby limiting the productive value of their land. Regulations that are seen by consumers, wholesale produce buyers, or food processors as ineffective in preventing problems, distinguishing lands with good biosolids management from poorly managed lands, or tracking lands to which biosolids have been applied could affect the overall market for agricultural produce within a given market area.

Regulations established by the GO need to be sufficiently conservative to not only deal with real problems of land productivity damage and concerns relating to public health and the environment, but also to address public perceptions and thereby protect the farmers' ability to sell agricultural commodities. A regulatory program that is based on typical or average conditions, and that does not address problems resulting from nontypical conditions, may cause all lands treated with biosolids or located near biosolids application sites, to come under suspicion of posing a health and safety hazard.

Several large wholesale produce and agricultural commodities buyers have already adopted policies precluding the purchase of crops from lands on which biosolids have been applied, apparently because of concerns over potential consumer reactions. This

reaction to a perceived problem indicates that the impact on farmers of lost commodity markets is potentially significant. In addition to Mitigation Measures 4-1 and 4-2, the following mitigation measure should be implemented to reduce this impact to a less-than-significant level.

Mitigation Measure 4-3: Track and Identify Biosolids Application Sites. A program to identify and track applications of biosolids on agricultural lands should be established to mitigate the potential perception by produce buyers and consumers that crops have been contaminated or damaged by biosolids applications. The program should allow for public access to information. The program should also identify previous biosolids incorporation sites and add them to the tracking system.

Impacts of Other Activities

Silvicultural Use

Impact: Changes in Soil Nutrient Properties and Resulting Effects on Productivity

Less is known about specific biosolids impacts on forest soils, timber production, and silvicultural activities because biosolids research has focused on agricultural soils, common crops, and home garden uses. However, the same basic principles of soil science and agronomy used to evaluate potential biosolids impacts on agricultural soils also apply to forest soils.

Application of biosolids at mature forestlands is much more difficult than application on agricultural lands and therefore beneficial effects on physical soil properties may not be as common as those on agricultural and rangeland soils. The physical property benefits would be expected to be more significant on new forest plantation-type operations, where soil incorporation is easier. Similar to agricultural and rangeland soils, chemical effects associated with the fertilizer value of biosolids are expected to be common and primarily beneficial. Overall timber production and forest yield would be expected to increase in most situations following biosolids incorporation. Adverse nutrient interactions and induced deficiencies or improper forest tree nutrition (such as from very high soil nitrogen and low phosphorous levels) can potentially cause wood quality problems (e.g., poor wood strength) in some tree species, but this effect is also likely to be very rare and, once recognized, easily managed with an overall soil fertilization program.

California forest soils are more commonly acidic than agricultural soils, and therefore the bioavailability of phytotoxic heavy metals added with biosolids after many years of soil incorporation may be greater. Plants, however, vary widely in their sensitivity to heavy

metals in the soil solution, with leafy vegetables presumed to be the most sensitive and most nonornamental woody plants the least sensitive. As with agricultural soils, potentially significant impacts on silvicultural sites, including reductions in forest productivity from soils with elevated heavy metals levels from long-term applications of heavy metals, particularly those not regulated under the 503 Rules, could occur under the proposed GO. Such impacts on forest soil are possible, but are most likely rare and would occur only in specific unusual conditions or combinations of unfavorable soil conditions and unusual biosolids chemistry. The chances of such an unusual combination of conditions occurring is increased under the proposed GO because it does not require complete testing of biosolids for all potentially phytotoxic heavy metals that could be added to forest sites. However, such adverse phytotoxicity effects on silvicultural operations are expected to be even more rare than for agricultural operations because of the presumed nonsensitivity of forest trees to heavy metals phytotoxicity in the soil concentration range expected to develop within the limits placed on biosolids loading. The impact is considered potentially significant. Mitigation Measure 4-1 should be implemented to reduce this impact to a less-than-significant level.

Horticultural Uses

Impact: Potential Soil Degradation at Recreation-Area Application Sites

Horticultural operations that may use biosolids include parks and golf-course landscaping, turfgrass production, cut flowers grown on small plots and container-grown landscape plants, and vegetable seedling plants for home-garden transplanting. Potential public health effects of horticultural uses are discussed in Chapter 5, “Public Health”. Although flowers and leafy vegetables are often very sensitive to nutrient imbalances and heavy metals toxicity problems, which could affect yield, quality, and appearance, such problems are also more likely to be noticed by horticulturalists and more easily addressed through soil management (e.g., liming to adjust soil pH, switching to a nonbiosolids source of organic soil amendment). Additionally, only one application of biosolids as an organic amendment in container-grown stock would be permitted; therefore, the potential problems from long-term metals buildup in the soil from multiple applications would occur only in recreation-area applications. The scale of operation in container-grown crops and the economics of most field horticultural crops will allow for intensive observation and management. Accordingly, the general agricultural soil mitigation measures are applicable to only the recreation-area horticultural uses and no other mitigation measures are required. As with silvicultural operations, soil and soil-amendment testing would be prudent and in the best interests, but at the discretion, of the operator.

Mitigation Measures: No mitigation is required.

Land Reclamation

Impact: Potential Soil Degradation

Reclamation activities typically would include incorporation of biosolids into infertile soil materials, such as those from gravel-quarry waste or mine spoils. In reclamation site applications, the intent of the application is to improve soil conditions so that a vegetative cover can be established for soil stabilization. Occasionally, more intensive land uses might be considered as part of a reclamation project, such as a park or athletic field. A program for topsoil salvage and topdressing is often included in the reclamation plan. Where the goal is to establish high-quality turf over the reclamation site, a program combining topsoil importation and soil improvement through incorporation of amendments such as biosolids is often implemented. Incorporation of biosolids into such materials would improve both the physical and chemical condition of the materials and would be beneficial. Land productivity would almost always be increased. The reclamation or soil improvement program, as developed by most professionals, would normally include a soil- and amendment-testing program, but one is not required under either the state Surface Mining and Reclamation Act, or the GO.

The proposed GO requirement differs for reclamation activities in that the biosolids do not necessarily need to be applied at agronomic rates for nitrogen, provided that impacts on water quality are managed. Maximum rates and annual and cumulative loading limits for heavy metals would still apply under the proposed GO. Heavy-metal phytotoxicity problems could occur in reclamation projects, affecting the growth of the cover crop. As with agricultural soils, the degree of heavy metal-plant impact is often related to pH. Because some mine spoils are extremely acidic from oxidation of pyritic compounds present in the rock waste materials, heavy-metal phytotoxicity may be more common at these sites. Often there may be a preexisting heavy metals phytotoxicity problem simply because of the inherent high level of heavy metals in the mine wastes or because of their acidity. In this case, biosolids applications can aggravate the problem, but also can be a part of spoils management and site stabilization, along with additions of other soil amendments, such as lime.

Mitigation Measures: Implement Mitigation Measures 4-1 and 4-2 described above for agricultural operations. This mitigation measure will reduce the impact to a less-than-significant level.