BMPs for Cranberry Agriculture

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The Washington Conservation Commission

by the

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and the Pacific Coast Cranberry Research Foundation

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Introduction

Cranberry Agriculture in Washington State

The majority of the Northwest's cranberry farms are small family-owned businesses operating with an average of 11 acres of working cranberry beds. Washington State's cranberry growers produce 15 million pounds of fruit per year, contributing $8.5 million dollars to the area's economy. There are approximately 130 cranberry farms currently in operation in Washington.

Cranberries are native to the United States wetland areas. Colonists were introduced to the fruit in the 18th Century. Washington's first cultivated cranberry vines were planted about 1883 with varieties grown in East Coast cranberry beds. Just prior to World War I, several hundred of acres of cranberry beds were planted for commercial cultivation. Currently, cranberries are the most valuable food crop grown in the Willapa watershed. In recent years, the variety of products produced with cultivated cranberries has expanded. Recent medical research has yielded a greater appreciation of the nutritional value of cranberries. At the same time, industry-sponsored studies have led to increased productivity, improved cultivation methods, better conservation of the environmental values of wetlands, and reduction of potential risks to water quality. Along the way, growers have become highly-trained agriculturists committed to sustainable management of their farms and responsible stewardship. Cranberry growers and their farms are a vital link to the sustainable economy, one of a few viable agricultural enterprises in southwest Washington. Their continued existence is crucial for the preservation of open space along coastal southwest Washington.

The cranberry varieties cultivated in Washington State--though not native to the coastal region-- are preferred for their larger berries. Washington's cranberries farms are located in the coastal areas of Pacific and Grays Harbor Counties. The Long Beach peninsula located just north of the mouth of the Columbia River, is home to approximately 30 farms. The Grayland area north of Willapa Bay supports about 100 farms.

The Cultivated Cranberry

The cranberry is a woody broadleaf, evergreen vine that grows into a low-lying dense mat over the cultivated beds. During the early part of June, the vines begin to flower. Berries form on uprights and reach maturity approximately 80 days after full bloom. Growers begin harvesting in late September. Cranberries thrive on peat or muck marshes, but have also been successfully cultivated in sandy soils. A number of environmental conditions are crucial to commercial production of high quality cranberry crops.

A suitable level of soil acidity is one of the most important conditions necessary for cranberry agriculture. Commercial cranberry beds require acid soil with a pH level in the range of 4.5 to 5.5. Natural peat soils meet this requirement. Sandy soils in high rainfall areas frequently have suitable pH levels. Commercial fields need suitable topography, sufficient sources of water for irrigation, frost protection and harvesting, and an adequate growing season. Well aerated, unsaturated soil is needed for optimum cranberry growth and production. Adequate drainage is necessary to avoid flood damage and saturated soil conditions. Yet, cranberry beds must also not be excessively drained because the organic soils may decompose and the beds settle.

Cranberry agriculture absolutely depends on a reliable supply of high quality surface and groundwater. It is crucial that growers manage water saturation levels in their fields to assure that vine roots are nourished with clean, fresh water. At the same time the vines themselves must be kept dry enough to thrive and inhibit fungal and pest infestations. Contrary to popular perception, cranberry agriculture is not carried out in submerged fields as is rice farming. Cranberry fields can be walked on, although growers are careful to limit entry onto the beds due to the damage caused by crushing plants and fruit. Cranberry farmers harvest their crops in one of two ways: (1) by either dry picking with a specialized machine or (2) by flooding the fields with water, dislodging and floating the berries into booms and conveyor belts.

Cranberry farms draw upon local water supplies, but also serve to stabilize and maintain water table levels and wetlands functions. Water is needed for frost protection in the spring and heat protection in the summer. Nutrients and pesticides are applied through water systems. To support cranberry agriculture, soils must have suitable properties: they should be permeable enough to allow water to move freely without saturating them, but not so permeable that water leaches out before plants can use it. The soils of cranberry beds must be able to hold water for a number of days during the harvest. While peat soils retain water and nutrients adequately, sandy soils require special management techniques to achieve the proper balance of nutrients and water saturation.

The Development of BMPs for Cranberry Agriculture

The concept of BMPs was developed as a means to address nonpoint sources through cooperative voluntary programs rather than more adversarial regulatory approaches. "Nonpoint sources can be defined as any source of water pollution not associated with a discrete conveyance." Nonpoint sources include runoff from fields, forest lands, mining, construction and contribute a wide range of pollutants to ground and surface waters including sediments, minerals, nutrients, pesticides, organic wastes, waste oils, and thermal pollution. In 1990, Congress enacted legislation to both assist and motivate the states to develop strategies to control nonpoint pollution. EPA later developed guidance for nonpoint pollution control in the coastal zone. The BMPs for cranberry agriculture are organized in accordance with

the scheme for nonpoint pollution control programs provided by EPA in its guidance to the states.

The term "best management practices" means a practice or combination of practices that is/are determined by a State (or designated areawide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation, to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals. (40 CFR Part 130).

In 1993, the Environmental Protection Agency (EPA) awarded the Pacific Conservation District a grant to support the Coastal Cranberry Initiative, a two-pronged program of applied research and policy development. First, the Initiative supported research into operating procedures aimed at reducing nonpoint pollution inputs. The research was performed at the facilities and experimental cranberry beds of the Pacific Coast Cranberry Research Foundation in cooperation with Washington State University. Second, the Initiative sponsored a series of monthly meetings to develop "best management practices." An Advisory Board composed of local cranberry growers formulated the BMPs through a consensus-based process led by a professional facilitator. Meetings were held in Grayland and in Long Beach from May 1994 to January 1995, with a final joint meeting in April 1995. The general public and state regulatory personnel were invited to attend and participate in all deliberations. After comments were received from the Washington Conservation Commission, additional meetings were held from April through August 1997 to revise and enhance the BMPs.

Growers recognize that the BMPs presented in this document are a “work in progress.” A full re-evaluation and – where and if needed – specific revisions of recommendations should take place at minimum every five years. It is critical that growers continue to actively seek out better and more current information in regard to all the topics covered in the BMPs.

The Pacific Conservation District served as the original sponsoring agency to secure the funding needed for this project. Following its formation, the non-profit Pacific Coast Cranberry Research Foundation (PCCRF) assumed administrative responsibilities for the project. Throughout the process, member cranberry growers showed their willingness to look for ways to demonstrate their commitment to protecting public water resources and to sound stewardship of their farms.

Rather than waiting to address problems after they arise, the growers have adopted a *pro-active* posture, formulating practices that would move their industry towards the most effective and cost efficient methods for enhancing production, conserving resources, and *preventing* pollution. Prevention was emphasized as less expensive and more successful than remedial actions. Throughout the process, the

growers looked for means to assist agencies to improve oversight of the cranberry industry and to assure that environmental safeguards are rational.

Once approval of the BMPs has been gained, the Pacific Coast Cranberry Research Foundation will begin implementation. First, each cranberry grower will be assisted in evaluating the full range of relevant practices used on his or her farm and identify areas for improvement. Individual farm conservation plans will be formulated to guide growers in attaining greater levels of consistency with the BMPs. During this next phase in the process, the sponsors also will look for incentives to encourage compliance as well as ways to remove obstacles that inhibit the implementation of BMPs.

Cranberry BMPs:
Agricultural Burning

BMPs for burning are aimed at promoting safety and reducing air pollution caused by agricultural burning. Cranberry farms, in comparison with other forms of agriculture, produce relatively small quantities of residues. The typical amount of pruning residues burned each year is approximately 500 to 1000 lbs per acre. This debris is usually placed quickly into numerous piles and burned when conditions are favorable. On rare occasions, growers utilize burning in fields of up to 5 acres.

Alternatives to Burning

Consider all the alternatives

Cranberry growers should consider alternatives to burning and compare costs and benefits of various options for waste disposal. Other possible ways to dispose of cranberry-related wastes include (1) through assisted or natural decomposition, (2) through pick up by neighbors for secondary uses such as in gardens as mulch, as horse or cattle bedding, as fill material, and if baled with wire, as erosion control material.

Due to the small amount of burnable waste materials produced by cranberry agriculture, it is unlikely that grower-driven central collection and re-use may become a routine and cost-effective practice. Mechanical mulching equipment used to assist the natural decomposition process is not practical or cost effective for cranberry growers because cranberry vine prunings are too small and damp to be easily processed. Likewise large tree stumps, the other major type of common burnable material associated with cranberry agriculture, are not practical to handle with standard mulching equipment.

Materials That May Be Burned

Comply with state laws regarding what may be burned

In general, cranberry agriculture produces a comparatively limited variety of woody debris, vegetation wastes, and other materials suitable for burning. Waste vines and refuse from vine prunings are the most common type of burnable waste. Small tree branches and stumps are also routinely burned. In addition, growers typically have a variety of debris associated with farm housekeeping such as old boxes, fencing materials etc. Growers must comply with state laws regarding what may be burned. Only vegetation, lumber or other wood that has <u>not</u> been painted, treated with preservatives or stains, or soaked in oil or grease may be burned. Waste vines and prunings should be disposed of quickly, and need no drying time to achieve proper combustion. Stumps should be dried for as long as possible to promote full combustion.

When Burning is Needed

Burn to dispose of prunings and tree stumps; to clear land and to reduce fire risks

Disposal of accumulated waste vegetation through burning may properly be undertaken in a number of circumstances. The principal reasons for burning are: to dispose of vine prunings and tree stumps; to clear land in preparation for establishing new beds; to reduce the risk of fire as debris accumulates, particularly in areas adjacent to forested lands or buildings; to clear cranberry bed edges and buffer strips, and to carry out routine area maintenance and normal housekeeping. On occasion, but not commonly, burning may be used to reduce spread of pests or diseases such as fungus and weevils and thus can serve as an alternative to pesticides. Burning can also be used as a method for removing unwanted variety of vines from the beds. To renovate less productive beds, burning destroys annual weeds, some weed seeds, most vegetative propagules, and shallow root perennial weed species. It also kills most soil-borne destructive insects and plant pathogens. Burning prunings kills blackheaded fireworm eggs on the underside of the leaves, all spores and mycelium of disease causing pathogens.

Best Conditions for Burning

Use General Common Sense

Cranberry growers should use common sense in relation to selection of the optimal time and conditions to start and feed a fire. All relevant fire hazard factors should be considered. All safety practices and rules should be observed. When smoke is observed on nearby lands, growers should act as good neighbors and investigate whether the fire may be accidental or unmonitored. Neighbors and the local fire department should be notified if there are indications that the fire is not under close control. All reasonable precautions should be undertaken to prevent wildfire, excessive, smoke, and nuisance to neighbors.

Consider Risks of Nighttime Burning

Growers should not start a burn less than 2 hours before sunset or feed a fire at night unless the burning is carried out in accordance with Best Management Practices. In considering whether to continue a fire after dark, growers should consider air moisture content, wind speed, and the availability of opportunities to burn during daytime hours. In most cases, when burning vines in piles, growers should let fires die down before dark. In cases where stumps are being burned, fires cannot be discontinued. The grower should assure that a person will be assigned responsibility for periodically monitoring burning stumps until they are dead out.

Observe Fire Safety Principles

Growers should observe all common sense fire safety management principles applying to outdoor burning in general. Specifically, the grower should place materials to be burned on surfaces and in places that will not burn. A firebreak around the pile sufficient to prevent spread through sparks or scatter of embers should be built. During periods of elevated fire risk, (dry weather in the spring, summer, and fall months and drought periods), growers should limit the size of burn piles. During all seasons, fires should not be built closer than 50 feet from the nearest building or forested area. Burning should not be undertaken during highest risk days unless absolutely necessary. Growers should always have nearby a good shovel and at least 5 gallons of water, a hose under pressure with water, or another device to extinguish fire such as construction equipment.

Consider Wind conditions

Wind speed is only one factor to consider in making the decision on when to burn. All fire hazard factors should be weighed together. If conditions create a high risk of fire, do not burn when the wind will scatter loose material or sparks. If fire hazard is low, such as on rainy days, a strong wind may be advantageous for achieving safe and full combustion. To the extent possible, burn when the wind takes smoke away from roads, homes, population centers, or other public areas. In coastal areas, the wind often shifts making it difficult to completely avoid sending smoke into populated areas.

Weigh Other Relevant Factors

Certain meteorological factors weigh against burning as a disposal practice. Burning should not be undertaken during a temperature inversion that would act to hold smoke and particulate matter close to the ground. Other air pollution episodes, likewise, create adverse conditions for burning. Growers must observe all "Burn Ban" days designated by the Olympic Air Pollution Control Authority (See References Chapter). Growers should always check with the local fire district or the Authority before burning to ascertain whether a ban is in effect. Growers should also inform neighbors who would be affected of their intent to burn. Growers should demonstrate consideration towards neighbors and local communities. Burning should not be carried out during holidays, or other neighborhood events if it is likely to cause a disturbance.

Duration of the Burn

Maintain the Fire Only As Long As Necessary and Safe

Growers should maintain the fire only as long as necessary to fully combust all materials. The fire should then be put out. If a fire creates a nuisance from ashes carried by the wind, or from smoke, it must be put it out. Fires should be fed when

burning conditions are optimal. If conditions change and the fire hazard becomes high, the fire should be put out.

Best Control & Monitoring Practices

Assign and Equip a Fire Monitor for As Long As the Fire Burns

A responsible person should be assigned to periodically monitor the fire as long as it is burning. During dry and high fire risk periods, higher levels of care should be taken. Sufficient fire response tools and water should be kept nearby in accordance with the level of risk.

Smoke Reduction

Use Proper Ignition Techniques

Growers should follow common sense practices on ignition techniques including those prescribed by the state for outdoor burning. Piles should be stacked as tightly as possible, while still ensure sufficient air circulation throughout. Parallel piling is best. A propane torch or another commercial lighting device should be used to raise a large area of the fuel to full combustion temperature. Burnable waste materials should be added after the starter pile is fully engulfed. Dirt should not be pushed into the pile. Tires may not be burned or used to start fires. Diesel should not be poured on the fire to ignite. A fan may be helpful in promoting full combustion.

Compliance with Permit Regulations

Obtain All Required Permits Before Burning

Growers must obtain permits before burning. Growers should observe all applicable rules for outdoor burning specified in burn permits.

Cranberry BMPs:
Erosion & Sediment Control

Introduction

Erosion and sedimentation pose problems for water quality maintenance and for soil conservation. Erosion control is an important component of non-point pollution programs because soil itself is both a contaminant and a carrier of other pollutants such as pesticides and nutrients. Erosion control also helps preserve the amount of topsoil present for growing as well as its qualitative properties. Topography, climate, soil characteristics, and vegetative surface cover are the most significant factors affecting the likelihood that the soil will erode. The Field Office Technical Guide issued by the Natural Resources Conservation Service (NRCS) provides erosion control information and recommendations for different types of soils and slopes. Good soil conservation practices limit activities that would compact soil and promote optimal drainage to maintain the health of organic soils.

In general, cranberry agricultural activities do not give rise to significant levels of erosion. In fact, many of the strategies recommended for reducing erosion and sedimentation are standard agronomic practices of the cranberry industry. Cranberry beds are located on flat ground. Uneven or sloping areas that are more subject to erosion are also highly disadvantageous to the maintenance of proper saturation for cranberry agriculture. Secondly, strict control of water flow through the cranberry beds is critical to successful growing and harvesting. The cranberry farm's irrigation systems tightly control water volume and velocity and therefore tend not to be subject to storm-related erosion events. The water systems often include water storage ponds that reduce sediments through settling before the water exits the cranberry beds. Thirdly, cranberry growers normally employ soil conservation practices, in that they work to maintain the longevity of cranberry vines over years and even decades. Vine health and longevity is routinely promoted through periodic sanding. Cranberry plants are only replaced when diseased or unproductive. It is also standard practice to avoid disruption or compaction of the soil. No annual tilling is involved in cranberry agriculture. The presence of year-round ground cover acts to minimize the chance of erosion even during periods of heaviest rainfall.

The water systems of wet harvest cranberry farms are composed of on-site ditches that lead to sump ponds or adjacent lakes. During most periods of the year, the farm's irrigation and drainage system is able to retain and control the movement of waters on site, allowing for recharge of the water table. However, flooding may occur during and after storm events and high tides, requiring discharge of excess waters into public drainage systems. .Public drainage ditches occasionally back up, but recovery of drainage capacity is usually quick. When release is necessary, waters flow directly from one cranberry bed to the next. In all areas, the lack of

topographic elevation assures that water velocity will remain relatively slow. Flume gates also provide the ability to control water velocity exiting fields.

Structures & Activities Associated with Erosion

Evaluate Sediment Sources from Cranberry Farm Structures

Water levels must be tightly controlled on cranberry fields to assure soil and plant health, to provide sufficient water for frost and heat protection, and for wet harvesting. Integral to the field's irrigation systems are the ditches and dikes that direct water to and from the cranberry farm. Ditches primarily serve as a device to ensure proper drainage of the fields so that the delicate balance of water saturation and oxygenation is maintained to keep the cranberry plants healthy and productive. It is critical to this drainage function that the ditches remain free of large debris and extensive vegetation that would slow the passage of water. Bare soil on the bottoms of ditches and on the tops of dikes can be the source of erosion. Dike sides, however, because of their slope, are the most likely source of sedimentation to cranberry farm waters. Wind erosion is rare in coastal cranberry agriculture, although it can be a problem if farm roads are only topped with sand, rather than grass.

Evaluate Sediment Inputs from New Construction & Renovation

Construction of new buildings, roads or new fields may give rise to erosion when appropriate control techniques are not used. New cranberry farm establishment or existing field renovation are the times of greatest soil disturbance. However, the absence of slope, the sponge-like quality of the soil, and the water control offered by the field's drainage ditches reduce the likelihood of erosion. In addition, cranberry vines are normally planted as soon as possible in developing new fields or renovating existing ones. If properly done, the cranberry's root systems will stabilize the soil within the first year.

Understand Sediment Sources from Cranberry Farm Operations

Dry harvest cranberry operations are different from wet harvest operations in relation to their water management systems. Dry harvest growers have more limited water supplies, their drainage ditches lead directly into the main public drainage ditches and they are less likely to have tailwater recovery systems. Many wet harvesters, on the other hand, have on-site abundant water supplies from ponds, lakes, or large sumps, and all have tailwater recovery systems to feed water back into the farm's drainage system. On occasion, wet harvesters use public drainage ditches to discharge excess waters in order to provide water supplies needed for harvest by adjacent farmers. To keep the water storage ponds and sumps free of debris and deep enough to hold sufficient quantities of water, growers need to dredge periodically. Dredging is also used in some areas to extract sand for periodic use to keep cranberry vines healthy and promote root growth. Sand is often spread when the cranberry bed is

flooded. Dredging and sanding activities may involve short-term particulate contributions to the cranberry bed's water supply.

Evaluate Sediment Sources from Adjacent Lands

Cranberry fields may be located adjacent to forestlands and natural streams that have been channeled to assure drainage. Some of these streams do not flow year round. Cranberry growers may engage in activities such as tree thinning or brush cutting on land adjacent to their fields. These activities may be sources of erosion and sedimentation.

Strategies for Reducing Erosion and Sedimentation

Cranberry growers should employ all appropriate techniques for **erosion and sedimentation *prevention* and sediment *capture.*** Many of these strategies are normal practices of cranberry agriculture.

Utilize Erosion Control Measures for Cranberry Bed Structures

The climate and rich soil found in coastal Washington cranberry beds encourage vegetation growth in ditch bottoms, and dike tops and sides. Within ditches, this vegetation must be kept to a minimum to ensure their proper functioning. Growers should maintain a continuous cover of grass or similar vegetation on the tops of dikes. Erosion from dike sides may be minimized by using wood lining.

In relation to irrigation waters, the grower should manage the velocity of water discharged to reduce erosion, particularly in regard to new cranberry beds where stabilizing vegetation has not yet been established. Growers with sump ponds should use them as holding ponds to settle solids before waters are released from the cranberry bed. Where indicated, growers should maintain a healthy vegetative cover to retain soil integrity in such critical areas as along streambanks, and on adjacent sloping lands. Structural measures taken to control erosion require supporting maintenance and repair. Holding ponds need to be cleaned. Dike tops may need to be re-seeded. Rodent burrows in dikes need to be repaired.

Use Erosion Control Measures During New Construction & Renovation Activities

Detailed BMPs that have been developed for construction sites should be referred to when engaging in new construction or renovation of existing structures. Particularly when undertaking the establishment of a new cranberry bed, care should be taken to prevent erosion from activities related to site leveling and the installation of cranberry farm irrigation equipment, roads, dikes, and buildings. Cranberry vines should be planted as soon as possible in order to stabilize the soil.

Practice Erosion Control in Cranberry Bed Operations

Growers should employ all reasonable sediment capture and removal techniques, including filter strips to receive and cleanse waters before exiting the cranberry bed and holding ponds to allow settling of solids. When engaged in activities such as dredging or sanding that may involve short-term inputs of soil or sand into the cranberry bed's water supply, growers should ensure an adequate amount of time passes for settling solids out of the water before allowing waters to exit the cranberry bed. Growers should refer where possible to guidance from the Soil Conservation Service's Field Office Technical Guide (FOTG) in assessing the likelihood that erosion and in determining appropriate control techniques.

Employ Erosion Control in Adjacent Lands and Riparian Zones

Cranberry growers should comply with BMPs set forth in the Washington Forest Practices Act regarding timber clearing and erosion control measures in riparian zones in adjacent forested lands. Care should also be taken to avoid sediment discharges into both year round and intermittent streams.

Cranberry BMPs:
Integrated Pest Management

Introduction

Growers must successfully manage pest species in order to profitably operate a cranberry farm. There are a number of insect pests, weeds, and diseases that pose serious challenges to the economic viability of cranberry farms. Environmentally sound and appropriate control techniques must be adopted for each pest taking into consideration that many of the pests can never be completely eradicated. Because these pests must be suppressed each year, growers should take advantage of the narrow windows of opportunity during which the pests are most susceptible to control techniques.

All neighboring growers share responsibility for preventing the proliferation and intensification of pest infestations. Growers must be cognizant that insufficient control may put the health of adjacent bogs in jeopardy. All growers therefore should place a high priority on cooperation. In addition, growers depend on the health of feral insects such as bumblebees and other pollinators for a successful crop. Care must be taken to prevent accidental poisoning of pollinators that benefit everyone.

Nothing in this document should be read to supersede or invalidate federal, state, and local laws and regulations that are in effect. The discharge of pesticides into waters of the state, whether intentional or unintentional, is a violation of the State Surface Water Quality Standards (Chapter 173-201A WAC), the State Water Pollution Control Act (RCW 90.48) and the Federal Clean Water Act. Intentional discharges of pesticides into surface waters require approval from the Department of Ecology as specified in the rules and laws noted above. The definition of “waters of the state” includes certain ditches associated with cranberry agriculture. Because the relevant laws are complex, growers should seek information and become informed about the rules governing discharges into state waters and the status of surface waters on or adjacent to their bogs. Growers may seek such information from staff of the Department of Ecology or from WSU Extension Services.

The pesticide label is a legally-binding document. Pesticide applicators are obligated by law to use the pesticide in a manner that fully complies with the label directions. A pesticide label defines how that chemical can be used and the crops to which it may be applied. It provides information on maximum doses, concentrations, and frequency of use, as well as on appropriate targeted pest, weed, or disease. The label lists other chemical or fertilizers that may be mixed with the pesticide and will state if it may be applied through a chemigation system. Precautions for worker and applicator safety are also presented. It is illegal to use a chemical in a manner that violates label requirements. The label may also contain information regarding the pesticide’s potential as a contaminant.

These legal regulations may change from time to time. Growers must stay informed of all effective rules in relation to the pesticides used on their cranberry farms, including worker protection rules promulgated by the Department of Labor and Industries. For specific, detailed, and up-to-date information on pesticide registrations, label requirements and other rules, growers should consult the annual *Cranberry Insect, Disease, and Weed Control Program* publication of Washington State University and other relevant documents.

The aim of IPM, in essence, is the adoption of a deliberative and thoughtful approach to agriculture. After considering and weighing all the options, the grower should make very conscious choices that take into account specific characteristics of the site to be treated, the potential for contamination risks, the efficacy of various pest management techniques available, and the economic costs and benefits of applications. The insights and understandings derived from each year's farming experiences, from scientific information, and from extension services, should be employed to continually improve risk evaluations and enhance farm practices. In order to make more informed judgments regarding risks and benefits, growers need to draw accurate conclusions from past experiences. Such accuracy depends on careful observations, adequate record keeping and thoughtful evaluation of the information gathered from each year's experiences.

Studies carried out by the EPA have indicated that producers often reap economic benefits by implementing IPM strategies. Used properly, IPM can reduce pesticide use, increase yields, increase net returns, and decrease economic and environmental risks.

Elements in the Practice of Integrated Pest Management (IPM)

Integrated pest management was recently defined by the Washington Legislature (RCW _____) to mean *a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically-sound manner to meet agency programmatic pest management objectives. The elements of integrated pest management include:*

(a) Preventing *pest problems;*

(b) Monitoring *for the presence of the pests and pest damage:*

(c) Establishing *the density of the pest populations, that may be set at zero, that can be tolerated or correlated with a damage level sufficient to warrant treatment of the problem based on health, public safety, economic, or aesthetic thresholds;*

(d) Treating *pest problems to reduce populations below those levels established by damage thresholds using strategies that may include*

biological*, cultural, mechanical, and chemical control methods and that must consider human health, ecological impact, feasibility, and cost-effectiveness; and*

(e) Evaluating *the effects and efficacy of pest treatments.*

Objectives and Strategies for Integrated Management of Cranberry Pests

Objective 1: Fully Consider Alternatives, Weigh Risks Carefully, and Select the Best Control Options

Strategy 1.001: *Understand All Available Options*

To make the best choices, growers must first understand the full range of available options for pest control including both chemical and nonchemical alternatives. Cranberry growers are presented with a changing array of control options having varying levels of efficacy depending on site-specific factors. Cranberry growers must seek out the information needed to keep apprised of the latest scientific findings and technological developments in relation to pest management options. This responsibility can be met through regular participation in the educational activities of growers associations, government agencies or University extension services, or through other actions that result in the grower acquiring a sufficient understanding of current pest management options.

Strategy 1.002: Consider Public Concern Over Chemical Controls When Evaluating Risks

The general public continues to demonstrate a very high level of concern regarding the amount and kinds of pesticides introduced into the environment by agricultural activities. The presence of residential areas surrounding cranberry farms makes it particularly important for growers to continually explore ways to decrease reliance on chemical control methods. To the maximum extent practical, growers should use cultural and nonchemical methods to suppress and control pest populations. In addition, it is often the case that addressing a pest problem in an aggressive manner early in its development will lessen the amount of chemical needed for successful control.

Growers should regularly seek the latest information on new biological and cultural control strategies under development and consider these and other nonchemical options in the overall evaluation of pest control methods. It is also important to support and track the progress of research on agents that are less persistent, less toxic, more specific and sufficiently effective.

IPM Objective 2: *Prevent Pest Problems by Using Cultural Practices to Enhance Plant Vitality and Natural Resistance to Pests*

Overall good cultural management is the key to growing vigorous and healthy plants that are less susceptible to pest attack and damage. Cultural practices to enhance plant vigor produce healthy, thick vines that can better compete with undesirable weeds. The susceptibility or resistance of cranberry vines to disease is, in part, a function of the health and vigor of the plants. Similarly, various conditions in the production bed affect the vigor of pests that attack cranberry vines. Growers should employ practices that: (1) increase plant health and vigor; (2) make conditions in the bed unfavorable for the outbreak of pests, competing plant species and disease agents; and (3) decrease the destructive activity of pests that are present. Using cultural practices to prevent pest problems, growers may lessen reliance on control methods, minimize financial expenditures, and reduce potential environmental impacts.

Cultural practices include removal of weeds, soil maintenance, fertilization practices, irrigation and drainage management. These practices should be planned to promote healthy pest-resistant or tolerant plants and reduce the need for chemical control. Growers may also plant disease-tolerant cranberry varieties if feasible. While prevention strategies may not wholly eliminate pests, they can reduce the chemical or nonchemical treatment rate at which pest management is achieved.

Strategy 2.001 Use the Proper Amount of Fertilizers

Plants deprived of nutrients essential for vigor and the proper functioning of their natural resistance mechanisms will be more prone to disease, less able to compete with undesirable weeds and more vulnerable to insect damage. By introducing too much nitrogen into the beds, growers may encourage rank growth-- a condition that promotes excess humidity and wetness in the vines. Overly moist and rank conditions are conducive to the spread of disease-producing pathogens and compromise the natural resistance of the vines.

Strategy 2.002: Properly Control Moisture

Growers should adopt irrigation and other water management practices that minimize the time that plants are either too wet or too dry during the growing season. Irrigation early in the morning allows more time for the plants to dry during the day. Poor drainage also can lead to excessive moisture and plant susceptibility. Growers should also avoid depriving plants of sufficient water through use of drainage system designs that move irrigation away from plants too quickly. Without sufficient watering, vines are stressed and more susceptible to pest insects and weeds.

Strategy 2.003: Use Cultural Techniques that Inhibit Disease Causing Agents

Wherever feasible, growers should implement cultural practices that eliminate or inhibit the growth and spread of disease pathogens. Periodic sanding should be employed to bury pathogen-infested duff. Weeds should be removed to allow for better air circulation to help vines dry. Growers should promptly and safely dispose of trash piles following harvest to remove sources of pathogens. When installing new beds, growers should only plant vines mowed from healthy beds. Transfer of soil, water, and plant materials from diseased beds to uninfested beds should be avoided.

Strategy 2.004: Flood Bogs to Reduce Insect Infestations

Flooding is an effective means to control certain major insect pests.

Strategy 2.005: Carry Out Routine Weed Prevention

Complete eradication of all weed species is not considered cost effective or always desirable. Routine efforts to mechanically destroy seed proliferation of weed pests are recommended. Growers should consider lowering the pH level of beds to aid in control of several weed species that are acid-intolerant. Self-cleaning screens can be employed to reduce spread of seeds through irrigation water. Growers should mow dikes and other surrounding areas to prevent weeds from moving into the bed and to reduce sources of seeds. Sowing dikes with weed-competitive types of grass will also help suppress unwanted weed species.

Strategy 2.006: Use Proper Berry Picking and Handling Techniques

Growers should use care in the picking and handling of harvested fruit to prevent excessive bruising that leads to the onset of fruit rot.

Strategy 2.007: Use Cultural Practices for Vertebrate Control

To reduce rodent populations, growers should keep dikes and adjacent areas well-mowed to limit food sources and encourage predation by hawks and owls. Birds of prey may be attracted to cranberry bed areas by using nesting boxes and perching poles. Trapping pests is another option. Household cats or dogs also reduce the numbers of pest vertebrates. Cribbing bog edges may also keep voles and other rodents out of cranberry beds. Deer and elk intrusions may be minimized by construction of fencing where feasible. (Additional practices are listed in the Wildlife Habitat Chapter).

Objective 3: Monitor for the Presence of Pests and Pest Damage to Evaluate Need for Control

Strategy 3.001: Visually Scout for Presence of Pests and Extent of the Pest Problem

Growers should conduct regular and routine scouting tours of cranberry bogs to visually inspect for pests and pest damage. By limiting the use of expensive pest control applications, careful scouting has economic as well as environmental benefits. In general, the scouting strategy used will depend on the characteristics of the site and the nature of the potential pest population. Growers should regularly refer to technical literature developed to assist in the determining the best monitoring approaches as well as procedures for determining the extent of the problem.

Because at times the evaluation of the nature and extent of any pest problem may be technically complicated, growers have a special responsibility to obtain the most current information on the best available monitoring techniques and seek professional or technical advice when needed. Growers should also employ predictive tools to increase scouting efficiency. These may include heat unit accumulation models, migration prediction systems, pheromone and light trapping networks. In relation to certain pest species, growers cannot adequately scout for evidence of the problem due to the absence of visual cues and the extreme rapidity with which the pests lead to substantial crop losses. Expert assistance must be relied on to anticipate the problem and time the response to such pests. Growers must maintain regular contact with extension scientists and professional organizations to obtain this needed assistance.

Careful scouting is one of the most critical elements of integrated pest management because it offers a means to strategically target control measures. Only with timely and accurate scouting, can growers pinpoint the areas needing treatment and schedule control treatments to coincide with the windows of vulnerability of the pests requiring control. Growers should carefully review all relevant materials published by the WSU Extension Services that address the specific factors that must be considered in developing adequate pest scouting and monitoring approaches tailored to the conditions found on each cranberry farm.

Strategy 3.002: Seek Professional Assistance to Accurately Identify Diseases and Extent of Damage

Cranberry diseases can change from year to year. Variations in weather, cultural practices, the repeated uses of certain pesticides often are factors that influence the development of new or different diseases. Growers must first accurately

identify the disease and its causal agent. An expert should be consulted when the disease is not familiar. Faulty diagnosis may prevent implementation of the most appropriate control measures.

Strategy 3.003: Record Trends in Pest Infestations

An inventory of current and historical pest problems, cropping patterns, and use of pesticides for each field should be maintained. Growers should comply with all state and federal requirements for keeping detailed pesticide application records. Growers should monitor and record trends in specific pests to increase the effectiveness of their management approaches. Accurate identification of type and location of pest problems is essential for proper selection and application of control technique. To improve future management decisions, growers should keep current pest maps and document pest types, severity, and treatments. In infested areas subjected to repeated pesticide treatment, growers may conduct soil bioassays to monitor for residual chemicals.

Objective 4: Establish Thresholds for Treatment of Pest Populations

Strategy 4.001: Determine Appropriate Economic Threshold Indicating Need for Control

Growers should limit applications to those providing substantial economic benefit. Eradication of weeds, insects and pathogens is not always desirable nor cost effective. Because economic threshold determinations may vary greatly depending on site-specific conditions, growers should refer to more detailed manuals and other literature and consult with technical experts in making such assessments. Growers should carefully review all relevant materials published by the WSU Extension Services that address the specific factors that must be considered in determining the appropriate economic thresholds for various pest species.

Strategy 4.002: Use Preventive Control Where Economic Threshold Determination is Zero

In certain cases, economic thresholds may be determined to be zero. If no effective treatment is available once a pest outbreak has been established, growers must act before infestation occurs. In relation to certain diseases, for example, growers must prevent the onset of the pathogens. Applications of protective fungicides are necessary. Such treatments, however, should only be applied during fungal spore release and infection periods.

Objective 5: Assess Risks of Control Options and Select the Most Appropriate Treatment

Strategy 5.001: Consider the Risks, Site Vulnerabilities and Uncertainties.

Growers should fully consider the risks and factors affecting resource sensitivity and vulnerability when making pest control choices. To stay informed, growers should regularly consult experts, read technical literature and extension service publications and participate in workshops held by research institutions, growers associations, and regulatory agencies. Growers should consider the uncertainties, particularly those associated with the chemical control options, when deciding whether or not to use a pesticide or selecting a pesticide to use. Growers should assess the impacts of chemical control options on *beneficial* plant and insect populations that serve as natural controls on pests.

Strategy 5.002: Weigh Risks to Surface and Groundwater Resources

Risks to surface and groundwater resources should be examined in each case and incorporated as a factor in pest management decisions. Growers should determine and act in accordance with the groundwater contamination potential of the site by assessing soil characteristics including soil permeability and other physical properties; the proximity of surface waterbodies; the slope of surface; depth to the water table, and the characteristics of surface deposits. The soil and physical characteristics of all sites including mixing, loading and storage areas should be fully assessed. If potential for impacts to sensitive sites exists, growers should use the least toxic compounds that are effective.

Strategy 5.003: Consider Vectors of Pesticide Contamination

Growers should consider all the vectors of transportation of pesticide contamination into ground and surface waters including vapor drift, runoff, leaching into groundwater, and spills.

Strategy 5.004: Maintain Up-to-date Knowledge of Characteristics of All Pesticides Used

Growers should maintain up-to-date knowledge of the characteristics of all pesticides used and *under consideration for use*, including the following factors: adsorption; volatility; degradation; toxicity; persistence; and all current label requirements. Growers should periodically read the entire label of each pesticide used. This knowledge should be used in selecting the appropriate pest control option.

Strategy 5.005: Consider Risks of Repeated Use of Pesticides Over Time

Growers should also consider the need to alternate pesticides. Repeated application of the same pesticides can rapidly select for resistance in certain pests and should be avoided where practicable.

Strategy 5.006: Choose Formulation Appropriate for the Problem

Variations in disease problems over time necessitates the tailoring of treatment choices to match new fungal populations. Growers should select the fungicide formulations best suited for the application system that will be used. For applications late in the season, less persistent fungicides should be used to minimize residues. Growers should also use the lowest effective rate of fungicide. Growers should not use a sticker-spreader unless required by the label or advised by expert recommendation.

Strategy 5.007: Consider and Use Natural Controls

Growers should seek information on the use of ecological and biological characteristics of insect pests to inhibit or reduce pest infestations. Where economically feasible, growers should select for use available natural controls such as parasitic nematodes. When natural controls are not available, growers should consider importation and establishment of parasites. Among the biological controls available or under development are: the introduction and fostering of natural enemies; the release of sterilized males of pest species; and the use of pheromone traps for mass trapping and for disrupting mating and other behaviors of pests. Research is underway to further explore other biological control techniques including the diversification of cranberry farm habitat and the use of pest-tolerant crop strains.

Strategy 5.008: Where Feasible, Consider Use of Chemigation

Chemigation can be an efficient, effective, and environmentally-sound way to apply pesticides that are suitable for this method. The application process including time spent mixing pesticides and subsequent clean up can be completed in under an hour, providing the shortest period of exposure for the applicator. Growers are better able to choose a time with little or no wind and therefore eliminate drift beyond the target area completely. In addition, larger droplets produced by the type of sprinklers used in chemigation are less susceptible to drift. Application of insecticides at night after dusk reduces the risks to certain non-target species including bats, pollinators, and birds.

Objective 6: Implement the Most Appropriate Treatment in an Environmentally Sound Manner

Strategy 6.001: Implement Control in Compliance with All Laws, Regulations, and Pesticide Label Directions

Applicators should obtain the latest federal, state and local directions for pesticide use and must fully comply with all the directions on pesticide containers in use. The pesticide label is a legally-binding document. Growers should periodically read the entire label to assure compliance. Pesticide applicators are required by law to use the pesticide in a manner that fully complies with the label directions. It is, however, legal to apply pesticides 1) more dilute than on the label; 2) at a lower rate than on the label; 3) less frequently than on the label; and 4) for pests not on the label, as long as the site or crop is on the label and other restrictions are observed. Pesticide applicators *may not* increase the concentration, increase the rate per acre, shorten the specified interval between applications; apply in chemigation unless specifically allowed on the label; or shorten the pre-harvest interval (minimum number of days between the last application and crop harvest). Pesticides are registered federally under the Federal Insecticide, Fungicide, and Rodenticide Act. Federal law also permits local registration within states under certain conditions to satisfy "special local needs."

Strategy 6.002: Avoid Off-target Application

Efforts should be made where possible to avoid overspray and drift. When applying pesticides, growers should follow label guidelines pertaining to wind speeds and equipment operation so that applications are contained to the target area. Where possible, growers should apply formulations using ground equipment, chemigation, or wiping to assure uniform coverage and minimize off-target exposure.

Strategy 6.003: Minimize Pesticide Usage

Growers should use the lowest possible rates and amounts of pesticides that will produce the desired level of control. Emphasis of control should be placed on insects, weeds, and diseases that are most harmful and cannot be allowed to infest cranberry beds. Application equipment should be calibrated frequently. Growers should spot treat pest infestation *if feasible*. Markers or dyes should be used to designate treated areas so that inadvertent repeat applications are avoided and efficacy can be monitored. Unless the specific label directions require otherwise, vines and beds should be dry before pesticide treatment in order to maximize efficacy. Water should be applied to granular formulations shortly after application, but limited to prevent puddling on the soil surface. Herbicide application rates should be reduced on sandy soils.

Strategy 6.004: Increase Uniformity of Pesticide Treatment

To avoid the need for re-treatment, growers should seek to improve and maintain pesticide application system's uniformity. Uniform delivery of control agents allows optimal coverage on the target parts of the plant as well as across the target area. Growers should determine and use the optimum amount of water, pressure, injection timing, etc. appropriate for each of the application systems used.

Chemigation is an appropriate application method only when pesticide application equipment uniformity, as measured by the Coefficient of Uniformity Test, is high. Growers should have their systems regularly tested and, where indicated, correct the performance problems before using chemigation as a pesticide application technique.

Strategy 6.005: Before Use, Conduct a Pre-chemigation Inspection

To assure that the chemigation system will perform satisfactorily, growers should inspect main and lateral lines for leaks and sprinkler nozzles for evidence of clogging. Growers should also survey the entire target area to verify that no people, pets or wildlife are on or near the area.

Strategy 6.006: Before Use, Assure Chemigation System Design Compliance

Before using an irrigation system to apply pesticides, growers should take steps to assure that the system complies with all current state and federal rules regarding the design of these systems. Safety equipment is required to prevent backflow of pesticides into water supplies. Chemigation systems must be fitted with a check valve, or loop, low pressure drain, vacuum breaker, low pressure shutoff switch, and an injection port on the discharge side of the pump. Growers may not inject chemicals into an irrigation system through the suction side of the pump. To assure optimal mixing of the pesticide and the irrigation water, the injection port should be installed at least 10 pipe diameters upstream from an elbow or "T." The injection port should also be located horizontal to the main or at a 45-degree angle or less up to the main. The inject port should extend to the center of the main to assure uniform mixing within the line.

Strategy 6.007: Before Use, Calculate the Injection/Rinse Out Time

Before using chemigation, growers should determine the amount of time required for a pesticide to travel through the irrigation system through the use of a dye test. Pesticide performance can be optimized by limiting operation of the system to the amount of time needed for uniform application. Pesticides may be left in the irrigation lines if too little time is allowed, resulting in less effective pest control. If the irrigation system is operated for too long, the pesticides may be washed off the target

area. Excessively lengthy pesticide injection times reduce performance; growers with large systems should install multiple injection points if performance is inadequate.

Objective 7: Minimize Input of Pesticides into Surface Waters

Growers should take all feasible steps to minimize direct input of pesticides into surface waters. The prevention of direct inputs of pesticides into waterbodies including ditch water is the most important step in reducing the potential for transport of pesticides off-site.

Strategy 7.001: To Minimize Contamination, Retain Water Within the Field System

Retaining water within the farm ecosystem is one of the most effective means to reduce the potential for adverse environmental impacts and is particularly important after the use of certain pesticides. Label requirements may mandate the length of time during which water must be held. Growers must comply with such label requirements. To increase margins of safety, growers should hold harvest water and irrigation water for greater periods then prescribed by the label or as long as practically possible regardless of the type of pesticide used. Additional retention time is advisable in order to allow maximum deposition and degradation of nutrients and contaminants. Growers should cooperate with neighboring farmers to assure that water is managed responsibly. Water may also be held in ditches to allow for degradation and dissipation of pesticide residues.

Strategy 7.002: Segregate Open Stream Flows from the Ditch Water Where Feasible

Where water flows through cranberry bed irrigation systems and tailwater cannot be retained for any significant amount of time, growers should review the options for segregating or isolating the open stream flow from the bog's ditch water. One option for separating cranberry field waters entails the installation of flumes or bulkheads at the intersection of perimeter ditches and interior ditches. Another means is the installation of perforated drainage pipe or a gravel surface in the interior ditches. A third alternative is the construction of a by-pass canal to re-direct water during fertilizer or pesticide applications. Tailwater recovery systems or constructed wetlands may be used to filter water containing pesticide residues.

Strategy 7.003: Properly Install and Maintain Water Control Structures

In closed cranberry field or marsh systems, growers should provide for proper installation and maintenance of all water control structures (i.e. gates, bulkheads, etc.) to assure that they remain water tight when holding water for an

extended period. In particular, growers should see that water control equipment is adequately water tight to prevent leaking of contaminated ditch water and to prevent loss of flood water during harvest. Bulkhead boards should also be checked, replaced and maintained regularly.

Strategy 7.004: Decrease Ditch Water Level Before Pesticide Application

As much as feasible, growers should decrease the water level in ditches before application of pesticides. If the water level in ditches is reduced, pesticides will better adsorb onto sediment particles and vegetation in the ditches. In addition, the rate of water flow will decrease, allowing a greater holding time and more opportunity for deposition of pesticides out of the water column.

Strategy 7.005: Maintain Proper Ditch Function

The advantages of slowing and holding water should be balanced with the need to closely control water levels on the bog to achieve optimum conditions for cultivation. Growers should clean ditches and waterways to assure rapid movement of draining water away from the cranberry field. Ditches filled with vegetation impede the movement of surface waters following heavy rains. However, if adequate soil drainage can be assured, growers should consider leaving a limited number of aquatic plants in the ditches during the growing season. Growers can take best advantage of aquatic plant's potential for pesticide removal by leaving ditch vegetation in place until late in the growing season, particularly in main ditches and outlet ditches.

Strategy 7.006: Before Application, Anticipate Severe Weather Conditions

Oncoming severe weather conditions should be anticipated in order to avoid pesticide application prior to downpours that can wash pesticides off the target area.

Strategy 7.007: Reduce Potential for Contamination from Chemigation

Strategies for reducing the potential for surface water contamination are currently under development. At present, several options have been identified, but none has been tested sufficiently to assure effectiveness. Therefore, a number of choices are available to growers where problems with surface water contamination have been identified and remedial actions are indicated. Where it is feasible to cover ditches, growers may install and maintain impermeable covering barriers (e.g. plywood, plastic film, non-corrosive metal sheeting, etc.) on all cribbed ditches within 15 ft on either side on sprinkler heads. By covering ditches, direct chemical inputs to

interior and perimeter ditch waters probably will be minimized. Where feasible, growers should consider installing cribbing or perforated drainage pipe and stone fill. Growers also choose to install either gear-driven sprinkler heads or part-circle sprinkler heads and wire mesh or plastic bucket sprinkler guards to minimize direct inputs of chemicals into interior and perimeter ditch waters. By locating sprinkler heads at least 10 feet from all ditches, growers may further reduce the potential for contamination. If re-location of sprinkler heads is impractical, growers should consider other methods for pesticide application including hand application immediately adjacent to waterbodies.

Objective 8: Evaluate the Effects and Efficacy of Treatments

Strategy 8.001: Evaluate the Record of Effectiveness

Growers should also compare and record information from treated and untreated areas to assess the performance of herbicides. Similar control areas should be used to evaluate fungicide effectiveness and determine the severity of diseases. Lack of disease symptoms in control areas can indicate a reduced need for control. If there are no significant differences in the infestation on treated and untreated areas, growers should re-examine control practices.

Strategy 8.002: Seek Advice from Technical Experts and Scientists

Growers should regularly communicate with technical experts in professional associations, extension services of Universities, and government agencies to seek information on the efficacy and effects of pest treatments. Growers should obtain and read available technical literature developed to assist in the determining the best options for pest control as well as procedures for monitoring problems and making economic threshold determinations.

Objective 9: Reduce Accidents, Overspraying or Underspraying

Strategy 9.001: Follow Worker Protection Standards (WPS) Rules

Growers must provide training and full notification to all employees regarding safe practices for pesticide handling and application. Growers must comply with all federal and state requirements regarding worker safety.

Strategy 9.002: Obtain Applicator Certification

Growers must obtain any licenses required by law for pesticide applications. In addition, special certification may be mandated if restricted use

pesticides are being applied. Growers should consider obtaining levels of training that exceed the minimum requirements.

Strategy 9.003: Regularly Calibrate Equipment

Growers can assure that the appropriate amount of pesticide is being applied and that the application is uniform over the target area only if the application equipment is properly calibrated. Pest control is less effective if the treatment is uneven. In addition, poor application practices give rise to unwarranted water quality risks. Growers must maintain application equipment in good working order and see that it is properly calibrated before use each spray season. Growers should acquire and use new more precise application equipment as the technology is improved.

Strategy 9.004: Mix Properly and Only the Amount Needed

No more than the amount of pesticide needed for the application should be mixed when preparing for application. Adjacent water and soils should be protected from spills or leakages. Equipment must not be left unattended while being filled with pesticides. Safety rules should be closely adhered to while mixing and loading pesticides including the use of appropriate clothing.

Strategy 9.005: Take Precautions to Avoid Leaks, Spills, and Backflows

In particular, growers should take precautions to ensure that pesticides do not leak from chemigation units when hoses are disconnected. Back-siphoning of pesticides into wells or surface water ponds must be prevented by the use of an approved back flow prevention device or air gap on the waterline when filling the application equipment.

Objective 10: Reduce Incidental Contact with Pesticide

Strategy 10.001: Assure no unauthorized entry onto Areas to be Treated

Growers should post adequate warning signs to prevent unauthorized entry onto the spray target area. Growers should scout the target area before application to assure that no people or pets are present.

Strategy 10.002: Apply during Optimal Weather and Social Conditions

Pesticide application during high wind conditions should be avoided because it may result in unnecessary drift and reduce the efficacy of the application. Growers should consult weather forecast before application and delay application if heavy rain, fog conditions or a temperature inversion are expected. The potential for creating an odor nuisance to neighboring property owners when applying certain pesticides such as Diazinon and Guthion should also be considered.

Strategy 10.003: Use Application Method that Reduces Drift

Applications should be carried out as close to the plants as appropriate and using as low spray pressure as possible. Nozzles that produce drops more resistant to drift should be used. Where possible, growers should select chemicals that do not require high pressure and fine droplets. Nozzles should be regularly replaced or cleaned. Anti-drift additives may be used to reduce drift.

Strategy 10.004: Avoid Excessive Overlap of Applications

Growers should avoid or minimize the overlap of treatments when using low volume applications of certain chemicals such as Lorsban4E, Diazinon AG500, Pyrenone, and other oil-based carriers. Overlapping application using booms and mist blowers are particularly associated with phytotoxicity, vine stress, or burning.

Objective 11: Prepare for Accidents

Strategy 11.001: Strategy: Keep Current Material Safety Data Sheets (MSDS)

Growers should keep two sets of accurate and current MSDS sheets for each pesticide product in use. One set should be kept with the pesticides. The other set should be kept in a separate location identifiable by all workers. Pesticide distributors also supply blank MSDS forms. All pesticide applicators, coworkers, and family members should be familiar with the health and safety information contained in the MSDS. Growers should comply with worker protection and safety rules.

Strategy 11.002: Monitor Chemical Levels in Applicator's Blood

Baseline blood test should be taken for all chemical applicators to assure that accurate evaluations of chemical exposure can be carried out after accidents as well as in the course of normal applications.

Strategy 11.003: Keep A List of Stored Pesticides Offsite

A current list of stored pesticides should be updated regularly and kept in a location away from pesticide storage facility. Growers should keep the local emergency management office informed of the contents and location of pesticide storage facilities.

Strategy 11.004: Develop a Detailed Emergency Plan

Each grower should develop an emergency plan that lists steps to take in response to a pesticide poisoning, spill, fire, or other accidents. The plan should include an up-to-date list of the names and telephone numbers of priority officials and others to notify of the emergency. Emergency numbers should also be posted in a clearly visible and easily accessible place. Growers should stay informed of the most current information on the type and location of services and equipment available to respond to all common forms of emergencies. In particular, growers should be familiar with the personnel and services of the local fire department and state hazard cleanup office. Growers should also acquaint themselves with the most appropriate and environmentally-sound responses to various situations. Certain techniques work well in water but not on land and vice versa.

Strategy 11.005: Prevent Exposure to Pesticide Spills

In case of a spill emergency, growers must notify the appropriate officials in the emergency management office and the Department of Ecology. (See References Chapter). Before beginning the cleanup, growers should take precautions to prevent people and animals from being exposed by closing off the site to those not involved in the cleanup. In cases of pesticide spills, spread of the material should be stopped by using absorptive material. Protective clothing and equipment should be worn during all phases of the cleanup. To assure personal safety, someone should be instructed to monitor cleanup crew activities.

Strategy 11.006: Employ Prudent Spill Clean Up Techniques

During cleanup operations, indoor spills should be ventilated. If the spill occurred near a waterbody, the top layer of soil should be removed and disposed of properly. Accidents involving release of granules or powders usually allow some recovery of spilled materials; however, care must be taken to avoid inhalation of airborne powders. Spills occurring on non-absorbent surface may be cleaned up using absorbent materials. If rainfall takes place before the cleanup is completed, spill areas should be covered with plastic to prevent contamination of runoff.

Strategy 11.007: Use Prudent After Clean-Up Procedures

After a cleanup, all reusable protective equipment and clothing should be washed. These should not be shaken out before washing. Disposable materials should be deposited in a safe container and dispose of in accordance with all laws and regulations. Cleanup personnel should shower after cleanup. Contaminated absorbent materials and recovered spilled and unusable pesticides should be disposed of in accordance with all pertinent laws and regulations.

Objective 12: Secure Areas Used for Storage and Mixing of Pesticides

Strategy 12.001: Design, Construct, Locate, and Secure Appropriate Storage Area

Facilities used for the storage and/or mixing of pesticides should be designed, constructed, located, and secured to reduce the risk of contamination of water resources and other sensitive areas. Growers should install a berm around the facility to prevent runoff of materials in case of a spill. Growers should develop a site-specific contingency plan to prevent contamination that may include the construction of berms around well sites. Spill response equipment should be easily accessible and stored nearby. Response equipment should include a first aid kit, absorptive material, shovels, and protective clothing. Fresh water should be available for washing eyes. Pesticide storage facilities must be ventilated to avoid build-up of fumes. They must also be separate from working and living areas. Precautions must be taken to avoid freezing of pesticides. Warning signs must be posted in accordance with federal and state rules.

Strategy 12.002: Properly Store Containers

All pesticide containers should be closed tightly. Fertilizers should not be stored in the same building as pesticides. Petroleum products should not be stored with pesticides or fertilizers. Containers of restricted use pesticides must be stored in a secured area when unattended. Pesticide containers should be dated to record time of purchase. Pesticides should be stored in the original containers. If a container is damaged, the pesticide should be carefully transferred to a clean alternative container. The original label must be attached to the alternative container.

Strategy 12.003: Comply with the Laws Regarding Container Disposal

Growers must comply with all laws – federal, state and local – and all directions contained on the pesticide label and MSDS regarding safe container disposal. Because federal, state and local laws may differ, growers should become

fully knowledgeable about them all. Growers should also look into and consider available recycling options. Liquid containers must be triple rinsed. Growers should use a pressure washing system if available. The resulting rinsate should be drained into the spray tank and sprayed in the fields in accordance with label requirements. Empty pesticide containers should be crushed or punctured so they cannot be reused and then delivered to an appropriate container collection site. Paper or plastic pesticide bags must not be burned, unless specifically allowed in label requirements. Pesticide containers should not be buried.

Strategy 12.004: Minimize the Quantity of Pesticide Purchased to Avoid the Need for Storing Pesticide Inventory

Growers should determine exact needs before purchasing pesticide to avoid obtaining unnecessary surplus pesticides that will have to be stored as inventory. Growers should only buy the quantity of pesticide that will be used within one year. Only the amount required for the application should be mixed and extended.

Strategy 12.005: Properly Dispose of Surplus Inventories of Pesticides

Growers may apply surplus spraying mixture to target areas, but must assure that label application rates are not exceeded. In relation to surplus pesticides that are no-longer registered, growers should consult the state agency with authority over such materials. In many instances, surplus inventory can be used unless the registration has been canceled or suspended. Unopened pesticide containers should be returned to the manufacturer. Surplus inventories of pesticides must not be disposed of on land or in sewers.

Strategy 12.006: Comply with All the Laws Related to Movement of Pesticides

Growers must adhere to all requirements relating to the transport of pesticides. Pesticides may only be moved in undamaged and labeled pesticide containers that are securely closed. Containers must be placed on nonabsorbent material and secured in the vehicle used for transportation. It is not legal to transport pesticides and produce in the same load. Vehicles carrying pesticides must be locked when left unattended. Pesticides may not be transported in the passenger section of a vehicle. Spill cleanup equipment must be carried in a vehicle transporting pesticides. Anyone transporting pesticides should be familiar with spill response procedures.

Cranberry BMPs:
Nutrient Management

Introduction

Fertilizers are applied to cranberry beds to remove limitations to yield and quality by supplying the plants with supplemental nutrients necessary for growth. Fertilization of the bogs begins in early spring and continues until fall. Time and rate of application varies with each individual bog. Fertilizers can be applied on the ground through irrigation (fertigation) systems, rotary spreaders, or motorized vehicles. Fertilizer application rates will vary for different varieties of berries and soil conditions. The actual amounts of nutrients applied on an individual farm must be adjusted in relation to crop prospects and the soil conditions on each bed. When done on a regular basis, soil or leaf analyses are recommended as an aid to determine fertilizer needs.

Cultural Practices

Minimize Fertilizer Use

Growers should install hardpan, clay or organic base under cranberry beds to minimize loss of nutrients through leaching and allow longer retention of fertilizers in root zone. Growers should adjust pH level to the extent feasible to promote availability of minerals.

Reduce Fertilizers in Runoff

Growers are encouraged to install buffer strips adjacent to surface waters receiving drainage from active beds. Harvest waters should be retained for as long as practically possible. Water levels in ditches should be lowered where feasible before application of fertilizers. Fertilizers will better adsorb onto sediment and vegetation in the ditches if water moves slowly through the ditches. Main drainage and outlet ditches should be cleaned to assure adequate soil drainage, but growers should consider leaving a limited number of aquatic plants for fertilizer removal until late in growing season.

Nutrient Management Techniques

Avoid Over Fertilization

Growers should avoid over fertilization of beds or lush areas within beds. Spot treatment should be considered where growth is irregular. Fertilizer application rates should be based on realistic yield goals.

Use Realistic Yield Goals

In setting yield goals, growers should consider a range of factors in relation to each bed. These factors include but are not limited to: (1) current conditions of the plants, (2) near-term weather conditions; (3) recent yield experience; (4) trends indicated by soil or plant tissue analyses; (5) visual and other historic cues; and (6) prospective berry set. To avoid excessive application, growers should avoid being too optimistic about the yield potential for the year. Historic yields can serve as a guide to the bed's potential. However, a low yield year can be followed by a very high yield year. The bloom should serve as the first meaningful indicator of the year's yield potential.

Maintain Records of Crop Yield, Plant and Soil Analyses

Growers should develop and maintain accurate recording systems for crop yield. Plant and soil analyses should be done in August to serve as a baseline for the following year.

Optimize Timing and Applications of Fertilizer

Growers should avoid applying Nitrogen before the bloom. To optimize crop recovery, growers should apply N in multiple small applications rather than fewer applications of large amounts. Fertilizer applications should be timed to correspond with crop demand. Crop demand is related to soil temperature, stage of plant or fruit growth, and the magnitude of the berry set. To avoid leaching, growers should avoid applying Nitrogen during fall and early spring, particularly on coarse textured soils. Other fertilizers may be beneficial to apply during plant dormancy. Growers should use slow-release nitrogen formulations such as fish meal where feasible.

Use Formulations that Reduce Risk of Leaching

Because ammonia ties to organic matter in the soil, growers should use ammonia-based nitrogen or forms of nitrogen that are not readily leachable.

Fertilizer Application Methods

Properly Operate and Maintain Fertigation Equipment

Growers must operate and maintain fertigation equipment in compliance with the relevant federal, state and local laws and regulations. Fertigation equipment is required to have safety features identical to those required for chemigation. Growers must calibrate fertilizer equipment each year to insure that the proper amount of fertilizer is being applied and that the application is uniform.

Store and Handle Fertilizers to Reduce Risk of Spills

Fertilizers must be stored and handled in a manner which minimizes the occurrence of accidental spills into surface or groundwater. Growers should store fertilizers in a dry covered area. Opened fertilizer containers should be resealed for storage.

Employ Proper Responses to Fertilizer Spills

Growers may recover and utilize spilled granular forms of fertilizer. Spilled concentrated liquid forms of fertilizer should be prevented from spreading by covering with sawdust or other absorptive material. Excess fertilizer may be applied to cranberry beds if application rates are not exceeded. Growers may also dispose of excess materials on suitable adjacent lands.

Apply Fertilizers During the Best Conditions

Proper drainage improves the efficiency of fertilizer applications. Excess water on the cranberry fields promotes runoff or leaching of the fertilizer, removing it from the root zone. Growers should avoid application when rainfall is expected that would cause fertilizers to be carried off site in surface or groundwater. Fertilizers should be applied when the plant foliage is dry. Growers should not undertake heavy irrigation after nutrients have been applied. Granular formulations of fertilizers require watering after application, but excessive watering should be avoided.

Cranberry BMPs:
Irrigation Water Management

Introduction

Cranberry growers manage water on cranberry fields to ensure sufficient moisture and adequate drainage for optimum plant growth. The following environmental considerations are directly related to water management practices:

(1) conservation of fresh water supplies;
(2) prevention of contamination of surface and groundwater by pesticides, fertilizers, or sediments; and
(3) strengthening plant health and resistance to pests and diseases.

Water management practices on cranberry fields differ from those used for other forms of agriculture because of the variety of ways water is used in cranberry agriculture. Water is used for disease and insect control, frost and heat protection and harvesting. Because of their periodic sizable water needs, many growers impound water adjacent to their fields. In addition to storage ponds and sumps, components of a typical water management system for a cranberry field includes irrigation systems, wells and drainage ditches and pipes.

The Varied Functions of Cranberry Farm Irrigation Systems

Growers depend on irrigation systems to protect against frost and heat as well as to fertilize, to apply pesticides and to deliver moisture needed to nourish plants. Frost protection is accomplished by sprinkling plants with water which, as it cools, gives up an amount of heat. The heat given up by the cooling water prevents the plant tissue from freezing. If a film of water is maintained by continuous application of water, the temperature of the plant tissue will remain above freezing, even as a layer of ice forms. In addition, during periods of high temperatures in the growing season, sprinkling acts as a means to utilize evaporative cooling to prevent scalding. High humidity and low wind speed may make it feasible to secure protection from frost and heat damage with an on-off cycle of spraying. When needed, constant sprinkling to secure frost protection is advised. Where feasible, an on-off cycle of sprinkling that uses the least amount of water that adequately affords protection should be used.

Water can be used and re-used within a cranberry farm , because its irrigation system and storage pond are often self-contained. Water can also be recycled among growers. Therefore, water use on a cranberry farm does not carry the same impacts as consumptive uses. Because of their weak root systems, newly-established beds require more frequent irrigation but less quantity of water. Because cranberry culture typically occurs in moist areas, irrigation needs are limited and comparatively small. Irrigation applications are often short in duration and

infrequent. Cooperative relations between growers should be established and maintained to assure high levels of water recycling.

Water uses on a cranberry bed have the potential to place soluble and insoluble fertilizers, pesticides and other chemicals in solution or suspension and carry them into adjacent waterways. Growers should use best management practices to prevent or minimize pollution identified in the nutrient, pesticide, and erosion control practices. Specifically, growers should, where feasible, practice tailwater recovery and recycle water to the maximum extent possible. After application of pesticide or fertilizer, all surface waters should be impounded for as long as possible. When the water quality of surface waters is acceptable, growers should release the water gradually to reduce velocity and prevent downstream flooding.

Water Conservation

Consider All Factors to Determine Irrigation Needs

The overriding objective of water conservation is to avoid waste by preventing water loss due to over-irrigation and/or excessive frost or heat protection measures. Indicators of waste include saturated soils, waterlogging, erosion, runoff, and leaching of waters and nutrients. Growers should consider a range of factors to determine irrigation needs and thus avoid over-irrigation.

Evaluate the Water Storage Capacity of the Cranberry Bed's Soil

A key factor to consider is the water storage capacity of the cranberry bed 's soil. Growers should fully understand the soils occurring on their farms including the order of the layers that affect their water storage capacities, and the organic content of the soils. Particularly with regard to new beds installed in areas in which cranberry agriculture has not traditionally taken place, growers should have a scientific assessment done of the cranberry field's soils and layers. Growers should also determine whether a subsurface impermeable layer is present which might indicate the existence of a perched water table. The advice of an expert should be sought if a perched water table is discovered beneath a cranberry field. The infiltration rate of the soils-- especially finer textured soils --fluctuates and should be monitored. Growers should evaluate the water storage capacity and irrigation needs of a cranberry bed based on the whole volume of soil supporting the vines including their full rooting depth. Surface dryness does not always indicate the need for irrigation. In addition, moss may create a surface seal limiting the infiltration rate.

Understand the Prevailing Environmental Factors

The prevailing weather patterns of the area are also a factor in evaluating the need for additional moisture. Irrigation scheduling should be based on consumptive use and actual soil and water conditions which are controlled by environmental

factors such as rainfall, temperature, relative humidity, wind, day length and crop condition. Growers should accurately monitor soil moisture on a regular basis to determine the appropriate time to irrigate.

Irrigate During the Best Conditions

Growers should irrigate their cranberry beds during the early morning when evaporation and wind losses will be lowest. The direction and velocity of winds should be taken into account to determine whether irrigation should take place and to assure uniformity of application and thus avoid dead strips. Newly established cranberry beds may need to be irrigated during the daytime to provide sufficient moisture for growth.

Minimize Non-target Irrigation

Growers should avoid non-target sprinkling to minimize waste. Part-circle sprinklers or re-alignment of sprinkler heads are methods to assure that spray is only directed towards the vines. Growers should also consider the feasibility of using alternative irrigation methods such as sub-surface irrigation if water can better be conserved.

Optimize Temperature Protection and Water Usage

To assure adequate frost and heat protection, growers should apply water at a rate of at least 0.1 inches per hour. The extent of frost protection needed is related to the hardiness of the growth stage of cranberries and the projected minimum temperature during the frost events. When determining heat and frost protection strategies, growers should also evaluate the presence of cold or hot spots on the cranberry fields. Temperature variations on the beds can best be determined if the temperature sensors are accurately calibrated and appropriately placed. Areas of the cranberry fields should be tested to document the variations. Growers should also evaluate the humidity, wind conditions and ambient air temperature to gauge the need for and timing of frost protection sprinkling. The uniformity of the irrigation system will also play a role in securing adequate frost and heat protection for all areas within a cranberry field.

Irrigation System Design, Operation, and Maintenance

Use Efficient Irrigation Systems

Irrigation systems must designed, engineered and constructed to make optimal and efficient use of available water supplies. The irrigation system must be designed to provide uniform coverage to avoid over-irrigation in some areas of the cranberry field and under-irrigation in other areas. Uniformity is critical for successful frost and heat protection. In addition, irrigation system efficiency and uniformity has been accredited with boosting yields because plants are more productive if kept in optimal moisture conditions.

Obtain High Levels of Irrigation System Uniformity

To achieve uniformity of application, the irrigation system must be designed properly and operated in accordance with the design specifications, particularly with respect to optimal system pressure. Irrigation system designs should minimize the use of 90 degree elbows that cause friction and pressure losses. The design should also entail the appropriate combination of lateral spacing, operating pressure, sprinkler model and nozzle size to achieve 90 per cent or above overlap of wetted diameter. If the coefficient of uniformity is below 80 per cent, the system should be updated or improved. Risers should be between 18" and 24" in height to maximize uniformity. The size of the nozzle should be gauged in accordance with its location. Newly established cranberry fields may temporarily need larger size nozzles to deliver larger quantities of water. Growers should assure that risers are upright, straight, and well anchored to limit wobble.

Operate Irrigation Systems to Maximize Uniformity

Growers should operate their irrigation system at the optimal pressure level. If the system pressure drops below the designed specifications, large water droplets will be formed and most of the water will be distributed around the outer edge of the pattern. Operation of the system above the desirable pressure range will result in the formation of mist and off-site drift. Extremely high pressure can cause the sprinkler arm to stand still or turn backwards.

Monitor Irrigation System Performance

Growers should carefully monitor the performance of their irrigation systems. Yield record should regularly be reviewed in evaluating the performance. Growers should measure the pressure of their systems with a pressure gauge. Growers should test the system uniformity and use the data collected from uniformity test to calculate accurately the system's irrigation rate. Aerial photographs may be used to obtain a more detailed picture of sprinkler patterns.

Perform Regular Irrigation System Maintenance

To conserve water, growers should optimize the performance of each component of their irrigation systems. Irrigation system components must be properly maintained. Growers should clean and inspect their irrigation systems regularly. Packing seals, pump valves, and other parts should be repaired when necessary. Filter baskets should be installed on intake lines to prevent clogging of nozzles or damage to pump parts. Growers should check mains, laterals and riser gaskets for leaks. Lateral irrigation lines should extend into drainage ditches where needed to assure complete drainage when cleaning, flushing or winterizing. Cleanout plugs should also be used to facilitate flushing of sediments and other debris that can clog lines. Irrigation lines should be cleaned in the spring and drained for the

winter at the end of the season. Riser strainers or filters can be used to prevent clogging of nozzles in lines with persistent problems. Ballcock shutoff valves or in-line strainer to also serve to aid in cleaning irrigation systems. Growers should consider new methods for cleaning pipes specifically aimed at clogging caused by bacterial debris.

Repair Irrigation Systems Properly

Proper irrigation system maintenance entails the utilization of methods of repair that avoid damage to lines, risers, and sprinkler heads. Damage to any of these parts can cause friction losses that affect the uniformity of water pressure in the system. Growers should avoid scratching interior of straight bore nozzles when removing any obstructions. Coated or plastic wire should be used to remove soft objects. Particular care should be taken when cleaning out nozzles with stream straighteners or vanes. Growers should routinely check for even small amounts of nozzle wear. The speed of sprinkler rotation should be tested to ensure at least 1 revolution per minute to be effective in frost control. Faulty sprinkler parts should be replaced if rotation speed is too slow. Growers should also prevent the sprinkler from excessive rotation speed that would cause unnecessary wear. Worn parts that cause risers to wobble should also be replaced. Where appropriate, galvanic corrosion should be monitored and controlled. Sprinklers should be painted to heighten visibility.

Wellhead Protection

Comply with Laws and Rules Pertaining to Wellhead Protection

Growers should be aware of and strictly comply with all state regulations aimed at wellhead protection. These rules are designed to prevent contamination of groundwater. Wells should be located away from areas subject to uncontrolled surface runoff or flooding. If a well is in such a location, measures should be taken to protect the well from runoff or flooding. Wells may only be installed by certified diggers. Construction of a protective berm would provide adequate protection. Landscaping or contouring of the site so water flows are diverted away from the well would also be sufficient.

Design and Locate New Wells to Provide Protection

Wells should be located away from potential sources of contamination such as storage and preparation areas for fertilizers, pesticides and petroleum products. Well should be constructed with durable materials. Wellheads should be fitted with a cover and tightly packed with benthic clay to prevent surface water and shallow ground water from entering the well.

The Cranberry Field Drainage System

Proper drainage is critical for the maintenance of productive soils and the cultivation of healthy and pest and disease resistant plants. Uncompacted soil conditions should be maintained to provide proper drainage and an aerated root zone for plant growth. Fine textured soils tend to be susceptible to compaction. Organic soils can be damaged by excessive drainage. If the water table is lowered too much, high levels of oxidation and soil shrinkage may result. Grower should seek expert consultations with soil specialists to obtain advice on organic soil drainage.

Properly Design, Install, and Maintain the Cranberry Field Drainage System

The bed's drainage system should have capacity to carry water away from the bed and regulate the water table level as management needs dictate. Cranberry bed drainage systems may include ditches, subsurface tiles, pumping systems, ponds, sumps, and constructed wetlands. To be effective, drainage outlets must flow freely. Blockage or insufficient drainage may result in excessive surface water runoff. Additional drainage is required when one of the following conditions is present: water accumulates on the surface for extended periods, erosion occurs, the vines or fruit shows damage from low aeration; fungal infestation increases; an anaerobic odor is present; or lower yields are produced. To prevent or improve poor drainage, growers should avoid over-irrigation and maintain free outlets or drainage discharge pipes. Submersible pumps may also be used to assist in drainage.

Consider All Relevant Factors in Design and Maintenance

The effective functioning of components of the drainage system depends on their proper design, construction and maintenance. Drainage system design requires specific knowledge of the soil, climate, and landscape conditions of a site. Precautions should be taken to prevent erosion. For example, ditch banks may be sloped at an angle to reduce the potential for slumping. Vegetation on ditch sides should also be maintained to prevent erosion. Ditches and pipes should be maintained in a clean, free flowing condition. Vegetation growing in ditch bottoms should be regularly mowed to promote a vegetative mat which does not impede flow. Growers should implement independent measures to promote drainage where regional drainage systems are temporarily inadequate. Low dikes can be built to prevent backflow.

Cranberry BMPs:
Wetlands Management & Wildlife Habitat

Introduction

Cranberry farms, on average, are relatively small agricultural operations. Some occupy plots of one or two acres. Others have more extensive parcels of dozens of acres. Cranberry growers are often constrained in their ability to provide habitat for wildlife due to their limited holdings. However, no matter what the size of the cranberry farms, there are opportunities for conserving wetlands functions, and improving the habitat values of lands adjacent to cranberry fields. It is important that cranberry growers fully understand the variety of benefits to wildlife that can be offered by the management measures listed in this section. Many of these measures and techniques are designed to "mimic" natural conditions and ecological functions. Growers recognize that they must continuously seek to enhance their understanding of natural systems to improve their ability to artificially re-create advantageous conditions. Cranberry bog workers should also be educated regarding the purposes and techniques of habitat enhancement, so they can avoid practices that are unintentionally harmful.

Conservation and Maintenance of Wetlands

Wetlands serve to protect shorelines from erosion by waves and storm surges. During floods and storms, wetlands act as natural storage areas: by retaining and gradually releasing waters, they reduce the impact of peak flows and droughts. In some cases, wetlands contribute to the recharging of groundwater. In addition, they filter and remove pollutants. Wetlands offer important food and habitat for wildlife during critical times of the years. They offer breeding, spawning, rearing, and feeding habitat for fish. They offer nesting and feeding habitat for migratory birds during the winter months.

Compared with other possible uses of the landscape, cranberry agriculture represents a commercial use that preserves many of the hydrologic features of the wetlands. Cranberry bogs maintain much of the water storage, cooling and filtration functions of the original wetlands. Furthermore, because they are essential to the commercial operation, these hydrologic benefits of wetlands are secured for the future by cranberry field management practices. Natural processes that would, in some cases, lead to the gradual filling in of wetlands are controlled in order to maintain the moist soil characteristics needed for cranberry agriculture.

As cranberry operations have expanded, growers have added to the net sum of lands having wetlands characteristics. To some extent, this contribution can be viewed as offsetting wetlands losses caused by other uses of the environment.

Cranberry agriculture also introduces ponds and other waterbodies into the landscape, often adding to the existing biological diversity of the area. Still growers recognize the ecological changes that were made in converting a natural wetlands into a cranberry farm: as working environments that benefit humankind, cranberry bogs do not have the full breadth of habitat values of pristine high-quality wetlands. In particular, certain species of plants and animals are not acceptable parts of the cranberry farm's biotic community. Growers cannot allow animals that cause significant damage to crops and cranberry field structures to have access to the habitat. Growers should, however, encourage use of their bogs and adjacent lands by a diversity of wildlife that is not harmful to bog operations.

Understand Wetland Benefits

Growers should become fully aware of the ecological benefits derived from wetlands functions. These benefits provide some of the key justifications for the emphasis society places on protection of wetlands. Growers should fully assess the value of their wetlands before making decisions about alterations and the design of mitigation measures.

Conserve Highest Value Wetlands

Growers should conserve highly valued forested wetlands areas. When expanding cranberry beds, growers should protect the highest value wetlands and cultivate those considered of lower value. Growers should seek assistance in identifying the relative importance of wetland areas in their possession. The estimated value of wetlands includes an assessment of its role in supporting indigenous wildlife as well as it hydrologic functions.

Retain Wetlands Functions

Cranberry beds should be created properly so that they retain the beneficial features of wetlands. For example, peat layers should be installed to promote water filtration that mimics the wetlands' natural cleansing functions. To the extent practicable, growers should avoid disrupting existing wetlands functions. Activities that would change wetlands into uplands should be minimized. Hydrologic functions should not be altered through disturbances of the soil. Growers should prevent the introduction of invasive plants. Changes in the area's microclimate should be minimized by limiting vegetation removal. Habitat values should only be limited to the minimum extent necessary for cultivation. Woody debris should be allowed to remain in the soil to the extent practical, so that the complexity of the soil composition is maintained.

Select Construction Methods With Least Impact on Wetlands Functions

Growers should minimize potentially damaging activities such as road construction and heavy equipment use. Mitigation strategies should be employed that include temporary measures to minimize impact. Growers should confine the

use of heavy equipment to dry periods and assure that the equipment is kept on the available high ground. Growers should use heavy equipment with the lowest available ground pressure. Projects should be carefully designed to achieve efficiency and avoid or minimize re-construction or repair.

Understand the Definitions of Wetlands

Growers should seek to understand the full range of definitions used by government agencies to delineate wetlands. Among the most important is that developed by the US Army Corps of Engineers (COE). It states that wetlands, "including those adjacent to waters of the United States, are defined as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions." "Adjacent" is defined as "*bordering, contiguous, or neighboring including those areas separated from other waters of the United States by man-made dikes, or barriers, natural river berms, and beach dunes."* In addition, growers should become familiar with state laws that may define wetlands differently.

Determine Wetlands Boundaries and Type

Wetland boundaries are determined by application of technical criteria for vegetation, soil, and hydrology. Growers should refer to the *"Federal Manual for Identifying and Delineating Jurisdictional Wetlands"* and request assistance on delineation questions from the relevant authorities.

Seek Up-to-Date Information on Wetland Activities Permits

Growers should also become conversant with permitting procedures used by government agencies. Many cranberry-related activities in wetlands are already authorized under the Nationwide Permit (NWP) for cranberry production activities. Certain activities fall outside the range of projects permitted under the NWP, particularly projects in riparian zones, ditches, and mature forested wetlands. If a project does not qualify under a nationwide permit, the grower must obtain an individual permit. In addition, growers must become familiar and comply with any special regional conditions placed on NWP.

Consider the Proper Use of Constructed Wetlands

Growers should become informed about the uses and performance of man-made "constructed" wetlands in treating polluted surface waters and consider such use for contaminated effluents that may be generated by the farm operations. When considering the use of constructed wetlands, growers should incorporate into the design, a means to exclude wildlife from areas holding contaminated water or plants and animals that have "taken up" contaminants.

Enhance Habitat Diversity

Prefer Native Species

When acting to broaden the diversity of habitat for beneficial or harmless wildlife, growers should demonstrate a strong preference for native species. Native species are more likely to be well suited for local conditions and provide quality habitat for native wildlife. Growers should selectively control or eradicate non-native species that have been officially designated as noxious or as pest species such as gorse. Growers should seek up-to-date advice from the relevant authorities on the most current list of exotic pest species of plants and animals that should not be introduced or maintained in the area.

Expand the Diversity in Adjacent Forested Lands

Woodlands adjacent to farms offer numerous benefits to wildlife. The key types of beneficial wildlife habitat found in forested areas include cavity trees, mast trees, brush piles, streams and riparian areas, and wetlands. Woodlands help maintain groundwater recharge functions, moderate air temperatures; create a visual screen; and reduce crop spray drift. Growers should maintain and promote trees of different size classes conditions, and growth stages to support wildlife diversity. Growers should consult with state and federal forest management agencies to learn about landscape management and habitat conservation planning opportunities available through forest stewardship programs aimed at small ownerships.

Increase the Amount of Large Woody Debris

Large woody debris, such as logs and stumps provide a wealth of habitat benefits to forested and aquatic ecosystems. In streams, they cause the formation of pools important to the diverse stream structure needed to support fish populations. They release nutrients vital to the productivity of lower trophic levels. They also provide cover from predators. Where feasible, growers should leave large woody debris in place. If removal is necessary, growers should stockpile pieces of large woody debris for installation in other places to improve habitat values.

Avoid Removal of Cavity trees

Cavity trees are created by fire, disease, flooding, drought or lightning. They provide shelter, food caches, escape cover, and nesting habitat. Growers should leave cavity trees in place where possible. They should only be removed for safety reasons. If there is an insufficient supply of cavity trees, growers should create them.

Avoid Removal of Mast trees

Mast trees provide wildlife with seeds, nuts, and fruits, particularly important for securing winter survival of certain wildlife. Large cone-bearing spruce are among the most productive mast trees in the Washington State. Growers should seek information from the relevant agencies to learn about native species that are highly useful for indigenous wildlife.

Provide Brush Piles

Hares and various birds utilize brush piles as habitat for nesting and cover from predators. Growers should build brush piles to create this beneficial habitat. However, growers should monitor and control vole populations that may also utilize brush pile habitat. Growers should locate brush piles far from the cranberry fields to minimize fire hazards and prevent spread of fungal spores and pests.

Properly Control Nuisance Animals

Growers should consider fencing or other techniques to control the occasional entry of elk, deer, and coyotes onto cranberry fields. When considering the use of fencing, growers should evaluate the importance of wildlife corridors for passage. Although not a frequent problem, elk and deer can contaminate fruit as they pass through cranberry fields. For smaller animals, growers may employ trapping as a means to control nuisance animals. Growers should avoid or minimize the need for such actions by eradicating the plants that are most attractive to nuisance animals such as sheep sorrel and sourgrass. Growers should understand and weigh all the benefits offered by wildlife in determining whether the animal species should be considered a nuisance. Burrowing behavior by coyotes is thought to cause serious damage to the structure of drainage ditches. However, coyotes also prey on voles, reducing their numbers. Voles are considered the most important source of burrowing damage to ditch structures.

Streams and Riparian Areas

Encourage Forest Diversity and Stream Protection

Riparian areas are extremely important to wildlife. Complex rules for riparian area management have been developed and applied to timber harvesting operations, based on the type of stream (intermittent or year round flow) and whether fish are present in the stream. The laws and rules promulgated to conserve and restore fish populations may apply to streams adjacent to cranberry fields: each grower must understand the official type and status of each stream that runs through his/her property.

The Washington Department of Fish and Wildlife does not require buffer zones next to drainage ditches or stream modified for agricultural purposes. However, growers should, wherever possible, comply with sound management practices – including the cultivation of minimum width buffer zones – developed for streams and riparian zones in forested areas. Natural vegetation should be left in a buffer strip along streams to provide shade, leaf litter and erosion control. A mix of

conifers and broadleaf species should be maintained in the riparian zone. Large woody debris should be left in streams to create the complex structure needed by fish species. Large woody debris provides cover from predators, moderates stream velocity, and adds nutrients into the system. Snags and cavity trees should also be retained in upland areas to provide useful wildlife habitat. Nest boxes may be placed in the riparian zone for wood ducks. Boxes for other riparian species may be developed in the near future.

Herb Zone Management

Cultivate a Diversity of Beneficial, Low Lying Plants

Within the herb zone surrounding the bog, growers should cultivate a diversity of beneficial, non-invasive, indigenous low lying plants. Plants should be selected that encourage insect-eating birds, raptors, owls and feral pollinators. Raptors and owls help control burrowing animals such as mice and voles. To achieve the optimal habitat values, growers should brush or mow the herb zone no more than once a year. Diversity can be promoted by alternating mowing to create two growth stages. Mowing should be avoided during the nesting season. Abandoned sumps may be filled with debris from spring ditch cleaning and converted for use as herb zone habitat.

Shrub Zone Management

Provide Nesting Habitat, Cover from Predators, and Food Sources

A shrub zone cultivated in the area adjacent to a cranberry field may provide nesting habitat, cover from predators, and sources of food. Browse for deer and bee forage are particularly beneficial. Growers should manage the shrub zone for plants favored by wildlife. Growers should become familiar which shrubs, such as borage and heather, that are attractive to pollinators. The potential for such plants to attract pest insects should also be evaluated. Growers should select shrubs to assure a mixture that will give wildlife year-round food, cover and a succession of blooms from late winter to the fall. Such a mixture may include small evergreens, stump sprouts, a variety of full sunlight shrubs, and a mix of deciduous and coniferous plants.

Nesting Boxes

Properly Place Nesting Boxes, and Other Useful Structures

Growers should place nesting boxes, platforms, and other useful structures for bats, swallows, wood ducks, owls, hawks, geese, and other birds along sump, pond, and bed edges to encourage wildlife diversity and obtain the benefits of natural controls on pests. The environment around boxes should be managed to encourage use by the targeted species and afford protection from avian and mammalian predators. Growers should discourage competitor species from taking possession of

the nesting boxes. One species in particular, starlings, is considered a serious threat. Growers are encouraged to use selective means of eliminating nest competition from starlings. Mammalian predators such as raccoons, rats, voles, coyotes, and domestic cats that pose a threat to desirable bird species should be prevented from gaining access to nest boxes.

Appropriately Design, Install, and Maintain Nest Boxes

Growers should obtain and follow carefully the most current information on the design, construction, and installation of nesting boxes. Information about new structures such as grassy tubes for certain species of ducks should be sought. (Government agencies and private organizations such as the Audubon Society and the Isaac Walton League have produced publications on this subject.) Nesting boxes must be cleaned each year immediately before the nesting season. Growers should assure that the nesting boxes are durable, easy to clean, rain proof and cool in the summer. The boxes should be installed at appropriate height and location for the species targeted. The boxes should have the optimal size opening. The opening should be the correct height from the floor of the box. The interior of boxes should provide ducklings or chicks a means to climb to the hole. The exterior of the box must prevent access to predators. Cedar shavings may be placed in the box to provide a nesting medium that is dry, soft, and repels bugs, fungus, and microbes.

Properly Time the Placement of Nest Boxes

Growers should assure that the box is available to the targeted species during the time of year needed for nesting.

Native Bee Habitat

Avoid Harm to Pollinators

Abundant and healthy native bee and other pollinator populations are essential for successful cultivation of cranberries. Because of the central role pollinators play in crop productivity, growers should review each farm practice to ensure that pollinators are not harmed unintentionally by cultivation practices. Growers should become and stay fully informed about the characteristics, behavior, and habitat requirements of pollinators. Growers should determine the relative toxicity of pesticides in relation to pollinators.

Encourage Forage Attractive to Pollinators

Where practical, growers should provide beneficial conditions that attract and support an abundant population of pollinators. Along cranberry field edges and in adjacent herb and shrub zones, growers should cultivate plants that are most beneficial to pollinators. Growers should obtain and review publications that indicate

the relative utility of various plants for pollinators. Growers should cultivate native plants used by pollinators that bloom before and after cranberries, so that forage is provided over a longer period of time. This forage also will not interfere with cranberry pollination. Plants should be selected and cultivated that present a low risk of weed production.

Cultivate Bee Forage and Consider Alternative Crops

Some cranberry farms contain areas of open space between the working beds. These "islands" of open space offer an ideal place for cultivating bee forage and habitat diversity. These areas should be maintained in low vegetation to allow adequate circulation, avoid shading, and prevent fire hazards. Growers should also consider cultivating alternative crops such as raspberries, blueberries, and holly trees, that will add diversity to the landscape.

Irrigation Ponds, Sumps, and Reservoirs

Install Screens in Intake Pipes

If juvenile salmon and trout are present in a stream, drainage ditch, or pond, growers must install wire mesh screens or other similar devices to prevent the intake of small salmon, trout, sculpin, stickleback or other fish into cranberry field irrigation systems.

Install Nesting and Protective Structures

Growers having large sump ponds should consider constructing nesting islands or other structures that may be utilized by wildlife. Large woody debris may be anchored to the side of ponds to provide shading and cover for fish and protection of young waterfowl from predators. Nest boxes should be installed along the pond perimeter where feasible. Raptor perch poles may be installed to promote natural control of rodent and vole populations. Bat boxes also are beneficial in providing insect control.

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