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ROADSIDE VEGETATION MANAGEMENT

Final Guidelines Document
for the Colorado Department of Transportation's
Maintenance Manual

Prepared for

Colorado Department of Transportation
Roadside Vegetation Management Advisory Panel

Prepared by

Paul F. Kohlhepp, Thomas G. Sanders, Cara C. Tackett, and Richard W. Walters
Department of Civil Engineering
Colorado State University
Fort Collins, Colorado 80523

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Paul F. Kohlhepp, Thomas G. Sanders, Cara C. Tackett, Richard W. Walters

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(S)
Department of Civil Engineering
Colorado State University
Fort Collins, Colorado 80523

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The purpose of this document is to outline roadside vegetation management practices recommended in Colorado. It is expected that the text of this document will replace the current chapter on Roadside Appearance in the CDOT Maintenance Manual.

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I. INTRODUCTION

Managing competing and unwanted vegetation is a major effort in the management of highway rights-of-way, involving substantial dollars and person-hours. The key components of a successful roadside vegetation management program should include the engineering, environmental, functional, and legal requirements of the highway system. Therefore, it is a goal of this document to outline and evaluate the current roadside vegetation management strategies used by the Colorado Department of Transportation (CDOT) in terms of their environmental impacts, their effectiveness, their social and economic effects and their impacts on human health.

Vegetation management is a key part of every highway system for four main reasons:

(1) it helps to maintain a safe driving environment by establishing and maintaining clear sight distances, ensuring road signs are visible and clear of vegetation, that roads are clear of shade that slows ice melting in winter, and that the structural integrity of the roads is preserved;

(2) it protects the investment in roads by preventing damage from unchecked vegetation growth;

(3) it provides a more visually appealing roadway;

(4) it controls noxious weeds and reduces fire hazards; and

(5) it promotes the establishment of indigenous plants which creates attractive roadsides and lowers maintenance costs.

The information presented in this document is based primarily upon the current Roadside Appearance chapter of CDOTs Maintenance Manual (dated 1990) and upon information obtained from seven States (California, Idaho, New Mexico, Ohio, Texas, Washington, and Wisconsin), two Counties in Colorado (Douglas and Adams) and a report by Auburn University's Department of Civil Engineering. The relevance of some items from other states to Colorado is uncertain and should be reviewed by CDOT personnel.

The purpose of this document is to outline roadside vegetation management practices recommended in Colorado. It is expected that the text of this document will replace the current chapter on Roadside Appearance in the CDOT Maintenance Manual. This document is intended to be used primarily by District Superintendents in developing specific procedures for roadside vegetation management within their Maintenance Districts. Thus, the bulk of this document provides general guidelines and recommendations, not procedural directives, to assist the Superintendents in customizing their maintenance needs. In some instances, however, detailed information on procedures is provided, such as in Section III, Guidelines for Levels of Vegetation Management.

A brief summary of the content of each section or appendix in this document is provided below in order to guide the reader's use of this document:

II. Federal and State Regulations. Provides a brief summary of regulations pertaining to highway maintenance activities.

III. Methods of Vegetation Management. Provides a brief description of six management strategies for vegetation management.

IV. Determining Levels of Vegetation Management. Provides a categorization of state and county highways based on traffic volume and adjacent property use and describes management practices for each category.

V. Mechanical Operations. Provides a detailed description of the available mechanical management techniques, including hand labor, mowers and brush cutters, special situations, and special precautions.

VI. Chemical Operations. Provides a detailed description of the available chemical management techniques, including types of herbicides, types of control, types of plants to be controlled, and factors contributing to effectiveness.

VII. Environmental Considerations. Provides a general description of the environmental impacts and safety considerations of the various management strategies.

VIII. Control of Noxious Weeds. Provides a comprehensive description of how to develop and implement a weed management plan, and presents specific control measures for Colorado's four designated weeds.

IX. Trees and Brush. Provides specific guidelines on control, removal, and disposal of trees and brush.

X. Wildlife Habitats and Wetlands. Describes the effect of vegetation management techniques on wildlife habitats.

XI. References. Provides a listing of documents that have been used in preparing or are refered to in this document.

APPENDICES

A. Federal and State Regulatory Contacts. Provides names, addresses, and phone numbers of persons to contact for additional information.

B. Background of County Designated Weeds. Lists all weeds controlled by Counties in Colorado, including physical description, growth cycle, and geographical distribution, and provides a common name cross-reference.

C. Chemical Control of Weeds: Herbicide Applications. Provides specific information on herbicide application rates for Colorado's four designated weeds.

D. Integrated Weed Management Glossary. Provides a glossary for terms used in this document.

E. Weeds Controlled in Colorado. Provides a tabular summary of the weeds addressed by the undesirable plant management plans that have been developed by each of the Counties in Colorado.

The scope of this document is limited to methods for management of established vegetation along roadside rights-of-way. Seeding and revegetation following highway construction is not addressed in this document, but is covered in the Colorado Seeding Manual.

II. FEDERAL AND STATE REGULATIONS[1]

This section provides a summary of federal and state regulations pertaining to highway maintenance activities and is intended to provide brief overviews only. For detailed information concerning these regulations and their direct impacts on highway maintenance and construction activities, consult the *Code of Federal Regulations (CFR).*

ARCHAEOLOGICAL RESOURCES PROTECTION ACT, PL 96-95, 1979, LAST AMENDED IN 1988

The purpose of the Archaeological Resources Protection Act (ARPA) is to secure, for the present and future benefit of the American people, the protection of archaeological resources and sites on public and Indian lands, and to foster increased cooperation and exchange of information between government authorities, the professional archaeological community, and individuals having collections of archaeological resources and data. A permit must be obtained from the federal land manager to excavate or remove any archaeological resource located on public or Indian lands or carry out associated activities. Therefore, when any archaeolocial resources are found on CDOT rights-of-way, construction and maintenance activities must cease until a permit for removal is obtained or further approval from a CDOT Environmental Specialist is given. The administrative agency for ARPA is the National Park Service.

AMENDMENTS TO THE CLEAN AIR ACT, PL 91-604, 1970, LAST AMENDED IN 1990

The Clean Air Act (CAA), originally passed in 1955, addresses the problem of polluted air in industrial cities and is intended to improve ambient air quality. It was subsequently amended to add provisions about the effects of sources of pollution; the 1977 amendments (PL 95-217) focused on toxic air emissions. The CAA gave the Environmental Protection Agency (EPA) authority to set three types of air standards: (1) National Ambient Air Quality Standards (NAAQS), defining the maximum concentration of air pollutants allowable; (2) New Source Performance Standards (NSPS), establishing allowable emission levels for various stationary sources; and (3) National Emissions Standards for Hazardous Air Pollutants (NESHAPs), setting emission limitations for which no ambient air quality standards exist. NAAQS authorized under Section 109 include both primary standards, which reflect the concentration level necessary to protect public health, and secondary standards, which are designed to protect the public from possible adverse effects of air emissions on vegetation, soil, water, wildlife, visibility, or climate. The CAA establishes emission standards for specific air pollutants that are particularly hazardous to health. Emission limits based on the Best Available Control Technology (BACT) are imposed on both existing and new sources. In setting hazardous air pollutant standards, the EPA must consider both the beneficial and adverse economic, environmental and energy impacts associated with the standard. All CDOT maintenance equipment, including vehicles, mowers, etc., must meet emissions standards established under the CAA. The administrative agency for the CAA is the EPA.

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[1] The summary of the Federal regulations presented herein is adapted from the report titled "Impacts of Environmental, Health and Safety Regulations on Highway Maintenance" NCHRP 14-9 (5) by Arthur R. Tarrer, Auburn University.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT, PL 96-510, 1980

Even with all of the preventive federal laws in place, accidental releases of toxic and hazardous substances inevitably occur. An estimated 50,000 toxic and hazardous substance disposal sites throughout the nation now reportedly pose significant health and environmental risks. It was in view of these problems that Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980 (amended by the Superfund Amendments and Reauthorization Act (SARA) in 1986). This law provides a system for identifying and cleaning up chemical and hazardous substances released into the air, water, groundwater, and on land. It expands the definition of "hazardous substance" to include substances listed in the Clean Water Act, the Resources Conservation and Recovery Act, the Clean Air Act, and the Toxic Substances Control Act. CERCLA established a trust fund, commonly called "Superfund," to pay for environmental contamination cleanup when no responsible party can be found. The trust fund is provided through a tax on crude oil, petroleum products, and 40 feedstock chemicals. CERCLA also requires that spills or discharges of over 700 substances in excess of 1 to 5000 pounds (depending on the substance) be reported immediately to the National Response Center established under the Clean Water Act. The Center is operated by the United States Coast Guard, which contacts the EPA and other federal agencies to initiate an emergency response. CERCLA and the Clean Water Act authorize three types of emergency responses: (1) immediate removal of material during emergency situations, (2) planned removal of releases where immediate response is not needed, and (3) remedial actions to permanently remove toxic and hazardous substances. In the event of a hazardous substance release the procedures to be followed are set forth in the National Contingency Plan. The plan was originally prepared under the Clean Water Act and includes procedures and standards for responding to hazardous releases. These procedures include discovery, investigation, evaluation and removal activities. As part of the plan, EPA is directed to list national priorities (National Priorities List) for cleanup of known or threatened releases. If the release of a Priority Pollutant occurs at a CDOT facility, proper cleanup must be conducted according to CERCLA mandates. The administrating agency for CERCLA is the EPA.

CLEAN WATER ACT, PL 95-217, 1972

The Clean Water Act (CWA) is the 1972 amendments to the Federal Water Pollution Control Act. The amendments control the discharge of toxic substances into surface streams. The first national effort to control water pollutants was through the Rivers and Harbors Act of 1899 which prohibited discharges into navigable waterways that could interfere with transportation. Additional water pollution control acts were passed in 1948, 1956, and 1965. The River and Harbors Act protected water bodies by imposing effluent limitations at the source of pollution (the discharge pipe), whereas the 1965 amendments defined pollution as a discharge above what can theoretically be adequately handled by the receiving body of water. The discharge limit provisions (Section 301a) and water quality standards (Section 301b and 302) were included in the 1972 amendments. Discharge permits, as part of the National Pollutant Discharge Elimination System (NPDES), set enforceable limitations on the types and quantities of pollutants which may be discharged. The 1972 act required the EPA to establish effluent standards for toxic discharge requirements for 34 industrial categories covering 129 toxic pollutants including metals, volatile compounds, corrosives, and pesticides. Discharges of these pollutants are required to use Best

Available Technology Economically Achievable (BAT). Toxic and hazardous wastes are generated primarily from industries and farmlands. Industries discharging directly into surface streams are regulated by an NPDES permit; discharges into municipal sewer plants are required to meet pretreatment requirements. CDOT must be concerned about the discharge of hazardous substances, such as pesticides or other solvents, into surface waters and groundwater. The administrating agency for the CWA is the EPA and in Colorado the Water Quality Control Division of the Department of Public Health and Environment. The CWA is currently up for reauthorization in congress.

CLEAN WATER ACT, SECTION 402(P), STORM WATER RUNOFF, 1990

This section of the CWA set forth the National Pollutant Discharge Elimination System (NPDES) permit application requirements for storm water discharges associated with industrial activity and storm water discharges from certain separate municipal storm sewer systems. Permitted industrial facilities (except construction activities) are required to contain and test storm water runoff for (1) any pollutants listed in an effluent guideline to which the facility is subject; (2) any pollutant listed in the NPDES permit for process wastewater; (3) oil and grease, pH, five day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), total phosphorous, nitrate plus nitrite, and total Kjeldahl nitrogen; and (4) certain pollutants known to be in the discharge. The regulations cover discharges from a wide range of general industry areas and activities including: (1) industrial plant yards; (2) immediate access roads and rail lines; (3) material handling sites; (4) refuse sites; (5) sites used for application or disposal of process waste waters; (6) sites used for storage and maintenance of material handling equipment; (7) sites for residual treatment, storage, and disposal; (8) shipping/receiving areas; (9) manufacturing buildings; (10) storage areas (including farm tanks); (11) areas of past industrial activities where significant materials remain and are exposed to storm water; and (12) construction activities. The administrating agency for the CWA 402(p) is the EPA and in Colorado the Water Quality Control Division of the Department of Public Health and Environment.

COLORADO UNDESIRABLE PLANT MANAGEMENT ACT, HB 90-1175, 1990

The Colorado Undesirable Plant Management Act has been given the short name "Colorado Noxious Weed Act" and was enacted in response and compliance to the Federal Noxious Weed Act. It mandates that all counties and municipalities, as of January 1, 1992, are required to develop an undesirable plant management plan for all unincorporated lands within their jurisdiction. The act defines "undesirable plant" and "weed" as any noxious plant. A "noxious plant" means an alien plant or parts thereof, which meets one or more of the following additional criteria: (1) it aggressively invades or is detrimental to economic crops or native plant communities; (2) it is poisonous to livestock; (3) it is a carrier of detrimental insects, diseases, or parasites; and (4) the direct or indirect effect of the presence of this plant is detrimental to the environmentally sound management of natural or agricultural ecosystems. According to the Colorado Noxious Weed Act, the board of county commissioners or the governing body of the municipality shall appoint an advisory commission and provide for the administration of the "undesirable plant management plan". Four plants in Colorado have been designated as undesirable and therefore must be managed. They are leafy spurge (*Euphorbia esula*), diffuse knapweed (*Centaurea diffusa*), Russian knapweed (*Centaurea repens*), and spotted knapweed (*Centaurea maculosa*). The board of county commissioners or the governing body may designate

additional undesirable plants (weeds). Also, the local governing body is charged with the right to enter upon any premises, lands, or places, public or private, for the purpose of inspecting for weed infestations.

EXECUTIVE ORDER 11988, FLOOD PLAIN MANAGEMENT, 1977

The general purpose of Executive Order 11988 is to avoid the long- and short-term adverse impacts associated with occupying and modifying floodplains, and to restore and preserve the natural and beneficial values served by floodplains. More specifically, Executive Order 11988 sets the following provisions: (1) to encourage a broad and unified effort to prevent uneconomic, hazardous, or incompatible use and development of the nation's floodplains; (2) to avoid longitudinal encroachment, where practicable; (3) to avoid significant encroachment, where practicable; (4) to minimize the impact of highway agency actions which adversely affect base floodplains; (5) to restore and preserve the natural and beneficial floodplain values that are adversely impacted by highway agency activities; and (6) to impose incompatible floodplain development. EO 11988 impacts primarily new CDOT construction projects with only minimal impacts on maintenance activities.

EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS, 1977

The general purpose of Executive Order 11990 is to promote practical alternatives to new construction in wetlands. It provides a policy and procedures for evaluation and mitigation of adverse environmental impacts to privately owned wetlands caused by new construction of federal aid highway projects. Federal agencies are required to avoid new wetlands construction unless the head of the agency determines that there is no practicable alternative, or that the proposed action includes all practicable measures available to minimize harm to wetlands. A CDOT Environmental Specialist should be consulted when a wetland environment is involved in maintenance or construction activities.

ENDANGERED SPECIES ACT, PL 93-205, 1973

The Endangered Species Act (ESA) provides the means to conserve ecosystems upon which endangered and threatened species depend, and establishes a program for conserving these species. The act further declares that the policy of Congress shall be that all federal departments and agencies (1) will seek to conserve endangered and threatened species and utilize their authorities to further the purposes of this act, and (2) will cooperate with state and local agencies to resolve water resource issues and conserve endangered species. CDOT's goal is to minimize the impact of maintenance and construction activities on the habitats of endangered and threatened species in accordance with a Memoradum of Understanding (MOU) with the Divison of Wildlife. A CDOT Environmental Specialist should be consulted when work in these habitats is involved. The administrative agency for the ESA is the Fish and Wildlife Service (Department of the Interior).

FEDERAL INSECTICIDE, FUNGICIDE AND RODENTICIDE ACT, 1988 AMENDMENTS, PL 100-532

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) established a regulatory program to control the manufacture and use of pesticides intended to kill, repel or control insects, rodents,

plants, trees, algae, fungi, bacteria, or other living organisms. The first federal legislation to control chemical pesticides was passed in 1910. The early law was designed to prevent the adulteration or misbranding of chemical pesticides to protect consumers against false advertising. Increased awareness of the health and environmental risks posed by new pesticides and their persistence characteristics (e.g., DDD and DDT), prompted Congress to pass FIFRA in 1972. The chief thrust of the law was to prevent unreasonable adverse effects on the environment and public health. Under FIFRA, manufactures must register all new pesticides with the EPA, which sets tolerance levels for residues before a substance can be used on food crops. Pesticides manufactured before 1972 must be examined to assure that they meet current safety standards. The EPA sets residue safety limits for raw (unprocessed) meat and agricultural products, while the Food and Drug Administration, under FFDCA, sets pesticide residue limits for processed foods. In considering registration of a pesticide, the EPA must evaluate not only its environmental effects, but also its economical, social, and health impacts. The agency may refuse to register pesticides judged unduly hazardous, or it may impose use restrictions, all of which must be printed on the label. Enforcement action can be taken against pesticide users who do not comply with the written restrictions. The EPA can also authorize that a pesticide only be applied by trained, certified applicators. The EPA has the authority to cancel the registration of a pesticide deemed an unreasonable risk. When the EPA determines that such a risk exists, it issues a "Rebuttable Presumption Against Registration" (RPAR), and provides the registrant an opportunity to provide evidence to the contrary before a final decision is made. Examples of canceled registrations include DDT, aldrin/dieldrin, 2,4,5-T/silvex, depone, mirex, and ethylene dibromide. All pesticides used by CDOT must be federally registered pesticides under FIFRA. The administrative agency for FIFRA is the EPA.

FEDERAL NOXIOUS WEED ACT, PL 93-629, 1974

The Federal Noxious Weed Act states that the regulation of transactions in, and movement of, noxious weeds is necessary to prevent and eliminate burdens upon and obstructions to interstate and foreign commerce and to protect public welfare. No person shall knowingly move any noxious weed into or through the United States without authorization from the U.S. Secretary of Agriculture. The Secretary is authorized to cooperate with other agencies (i.e. states, territories, districts, farmer's associations) to eradicate, suppress, control, prevent, or retard the spread of any noxious weed. The cooperating state or other governmental agency shall be responsible for the authority necessary to carry out the operations of this act.

FEDERAL WATER POLLUTION CONTROL ACT, PL 92-500, 1972

The objective of the Federal Water Pollution Control Act (FWPCA) is act is to restore and maintain the chemical, physical, and biological integrity of the nations waters. In order to achieve this objective, it was declared national policy that (1) discharging toxic pollutants in toxic amounts be prohibited; (2) federal financial assistance be provided to construct publicly owned treatment works (POTW); (3) areawide waste treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants in each state; (4) major research and demonstration effort be made to develop technology for eliminating the discharge of pollutants into navigable waters, waters of the contiguous zone, and oceans; and (5) programs for controlling nonpoint sources of pollution be expeditiously developed and implemented so that the goals of this act can be met through the control of both point and nonpoint sources of pollution.

The administrative agency for the FWPCA is the EPA and in Colorado the Department of Public Health and the Environment.

FISH AND WILDLIFE COORDINATION ACT, PL 1024, 1956, AMENDED BY PL 98-498, 1984

The Fish and Wildlife Coordination Act (FWCA) was passed to recognize the contribution of wildlife resources to the nation and the increasing public interest in these resources caused by economic expansion and other factors. Its purpose is to ensure that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs through the effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation. It further states that the Secretary of the Interior is authorized (1) to provide assistance to and cooperate with federal, state, and public or private agencies and organizations in the development, protection, raising, and stocking of all species of wildlife, their habitats, and to provide public shooting and fishing areas including access easements across public lands, and to carry out other measures necessary to implement these purposes; (2) to make surveys and investigations of wildlife in territories of the public domain, including lands, waters or interests acquired or controlled by any agency of the United States; and (3) to accept donations of land and contributions of funds to further the purposes of this act. CDOT's responsibilities under the FWCA are similar to those of the ESA, in which efforts should be made to minimize the impacts of construction and maintenance activities on wildlife habitats. The administrative agency for the FWCA is the Fish and Wildlife Service (Department of the Interior).

HAZARDOUS MATERIALS TRANSPORTATION ACT, PL 94-56, 1975

The Hazardous Materials Transportation Act (HMTA) of 1975 gives the Department of Transportation (DOT) authority to regulate the shipment of substances that may pose a threat to health, safety, property, or the environment when transported by air, water, rail, or highway. DOT regulations require special packaging, placarding and routing for hazardous materials. The transportation of hazardous materials was first regulated by the federal government in 1865 to protect railroads from poorly identified and packaged explosives and ammunition. The list of hazardous substances was expanded through the years to include additional substances, e.g., flammable liquids and gases, and to cover other modes of transportation, e.g., air, water and highways. The HMTA consolidated a variety of agencies and laws regulating different substances and transportation modes. Enforcement of materials traveling by a single mode of transport falls to the DOT branch with jurisdiction over that type of transport, i.e., the Federal Aviation Administration, the Federal Highway Administration, the Federal Railroad Administration or the United States Coast Guard. The administrating agency for the HMTA is the Office of Hazardous Materials Transportation (Department of Transportation).

NATIONAL ENVIRONMENTAL POLICY ACT, PL 91-190, 1969

The National Environmental Policy Act (NEPA) was passed in recognition of the profound impact and interrelatedness of human activities of all components of the natural environment, particularly the issues of population growth, high-density urbanization, industrial expansion, resource exploitation, and new, expanding technological advances. It also recognized the critical

importance of restoring and maintaining environmental quality to the overall welfare and development of humanity. It declares that the continuing policy of the federal government, in cooperation with state and local governments, and other concerned public and private organizations, is to use all practicable means, including financial and technical assistance, to foster and promote the general welfare, to create and maintain conditions under which humanity and nature can exist in productive harmony, and to help fulfill the social, economic, and other requirements of present and future generations. In order to carry out this policy, the federal government must use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate federal plans, functions, programs, and resources so that the nation may (1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations; (2) assure safe, healthful, productive, and aesthetically and culturally pleasing surroundings; (3) attain the widest range of beneficial uses of the environment without degradation or risk to health or safety, or other undesirable, unintended consequences; (4) preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment which supports diversity and variety of individual choice; (5) achieve a balance between population and amenities; and (6) enhance the quality or renewable resources and approach the maximum attainable recycling of depletable resources. The administrative agency for NEPA is the EPA.

OCCUPATIONAL SAFETY AND HEALTH ACT, PL 91-596, 1970

The Occupational Safety and Health Act (OSHA) is the primary federal law regulating toxic substances to protect workers in the workplace. The federal law was passed as a result of increased public concern about workplace hazards and the effects of exposure to hazardous chemicals. Before passage of the law, worker safety was the responsibility of state agencies and labor groups and federal safety requirements were confined to specific industries (e.g., mining, railroading, and longshoring). The main provisions of the act dealing with toxic substances include: (1) to limit exposure to various chemical substances that could induce acute or chronic health effects, (2) regulating substances that may cause cancer, (3) informing employees of the dangers posed by toxic substance through Material Safety Data Sheets, and (4) requiring employers to maintain medical and other records to track the development and incidence of occupationally induced disease. OSHA has established standards for 22 toxic or hazardous substances and 402 toxic air contaminants. In setting standards, OSHA evaluates three types of health effects: acute (immediate), chronic (long-term), and carcinogenic (able to cause cancer). OSHA must show that a "significant risk" exists before it issues a health standard, and that a standard must be feasible, i.e., it must adequately assure that no employee will suffer material impairment to his or her health to the extent that is "capable of being done." OSHA standards include a Permissible Exposure Limit (PEL), labeling, protective equipment, control procedures, and monitoring requirements. OSHA protects CDOT workers by establishing safety requirements for the use and handling of toxic substances. The administrative agency for OSHA is the Occupational Safety and Health Administration.

PRESERVATION OF HISTORICAL AND ARCHAEOLOGICAL DATA ACT, 1979

The purpose of the Preservation of Historical and Archaeological Data Act (PHADA) is to provide for the preservation of historical and archaeological data (including relics and specimens) which might otherwise be irreparably lost or destroyed as a result of (1) flooding, the building of

access roads, the erection of workers' communities, the relocation of railroads and highways, and other alternations of the terrain caused by construction of a dam by any agency of the United States, or by any private person or corporation holding a license issued by any such agency or (2) any alteration of the terrain caused as a result of any federal construction project or federally licensed activity or program. Like the ARPA, PHADA protects archaeological resources found on CDOT rights-of-way. A CDOT Environmental Specialist should be consulted when areas of concern are involved in maintenance activities. The administrative agency for the PHADA is the National Park Service.

RESOURCE CONSERVATION AND RECOVERY ACT, PL 94-580, 1976

The last major environmental statute passed is the Resource Conservation and Recovery Act (RCRA) of 1976, as amended in 1984. RCRA completed the circle of environmental laws enacted over the previous six years, focusing on recycling and disposing of solid wastes. The law is divided into eight subsections; the three subsections of primary importance include provisions to regulate solid wastes (Subtitle D), hazardous waste (Subtitle C), and underground storage tanks (Subtitle I). The law originally was drafted as a solid waste recycling and disposal law to eliminate open dumps; however, implementation has focused heavily on regulating hazardous wastes. The regulations promulgated by the EPA established a cradle-to-grave system of controlling hazardous wastes. Manifests for all hazardous wastes transported off-site are required. Hazardous wastes are defined under the law as those waste materials exhibiting certain characteristics (i.e., ignitability, corrosivity, reactivity, and toxicity) or are specifically listed by the EPA. Standards have been promulgated to regulate the generation, storage, transportation, treatment and disposal of hazardous wastes. In the 1984 amendments, the owner of underground storage tanks containing petroleum products and regulated substances were required to notify the states of the existence, size, age, type, and uses of all underground tanks. EPA law also developed regulations concerning leak detection and prevention, and corrective actions that will be required in the event of a leak. The Resource Conservation and Recovery Act also addresses the transportation of hazardous wastes. Transporters of hazardous waste must register with the EPA and carry hazardous waste manifests required under RCRA, and must comply with all DOT rules concerning labeling, packaging, and placarding. If bulk shipments are traveling by rail or air, DOT shipping papers are required rather than EPA hazardous waste manifests. RCRA regulates all CDOT underground storage tanks (UST), all transportation and disposal of hazardous wastes generated during construction and maintenance activities, disposal of all solid wastes generated, and storage of hazardous wastes. RCRA operating permits must be obtained for all CDOT USTs, for any CDOT Treatment, Storage and Disposal (TSD) facilities and manifests must be maintained for the transportation of hazardous substances. The administrative agency for RCRA is the EPA.

SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT, PL 99-499, 1986

The Superfund Amendments and Reauthorization Act (SARA) sets specific training requirements, funds training programs, and delegates responsibilities to OSHA and the National Institute of Environmental Health Sciences. SARA requires 40 hours of classroom and 24 hours of site specific training for nearly all workers on hazardous waste site cleanups, at commercial hazardous waste treatment, storage, and disposal facilities, and for industrial workers who will act as hazardous materials first responders. OSHA has promulgated draft regulations to cover the SARA

training and working condition requirements. SARA Title III-Emergency Planning and Community Right-To-Know regulates chemical storage by requiring notification of Local Emergency Planning Committees (LEPC) of storage of hazardous and extremely hazardous materials in excess of threshold planning quantities. Reportable releases, location of chemicals in plants and safety information on the chemicals is required. The administrative agency for SARA is the EPA.

SAFE DRINKING WATER ACT, PL 93-523, 1974

While the CWA focused on surface water quality, the Safe Drinking Water Act (SDWA) was passed in 1975 (and amended in 1986) to protect groundwater and drinking water sources. The law requires the EPA to establish recommended maximum contaminant goals (RMCG) for each contaminant which may have an adverse effect on the health of an individual. Two types of drinking water standards were established to limit the amount of contamination that may be in drinking water: primary standards with a maximum contaminant level (MCL) to protect human health and secondary standards that involve the color, taste, smell or other physical characteristics of a drinking water source. The SDWA stipulates 83 contaminants for which regulations must be developed by 1989. These include: 14 volatile organic compounds, 29 synthetic organic compounds, 13 inorganic chemicals, four microbiological contaminants, and two radiological contaminants. A second major provision of the SDWA is the regulation of underground injection of toxic chemicals. Liquid wastes are sometimes disposed of by injecting them into underground wells, and controls are needed to assure that this will not damage the quality of aquifers. Five classes of underground injection wells were established in this provision, and Class IV wells where hazardous wastes are injected into or above a formation within one-quarter mile of an underground source of drinking water were to be phased out. Under the 1986 amendments, states must adopt a program for wellhead protection, which must include the surface and subsurface surrounding of a well or well field through which contaminants are likely to approach a well. The administrative agency for the SDWA is the EPA.

SOLID WASTE DISPOSAL ACT, PL 93-611, 1975

The objectives of the Solid Waste Disposal Act (SWDA) are to promote the protection of health and the environment and to conserve valuable material and energy resources by: (1) providing technical and financial assistance to state and local governments and interstate agencies for the development of solid waste management plans (including resource recovery and resource conservation systems) which will promote improved solid waste management techniques (including more effective organizational arrangements), new and improved methods of collection, separation, and recovery of solid waste, and the environmentally safe disposal of nonrecoverable residues; (2) providing training grants in occupations addressing the design, operation, and maintenance of solid waste disposal systems; (3) prohibiting future open dumping on the land and requiring the conversion of existing open dumps to facilities which do not pose a danger to the environment or public health; (4) assuring that hazardous waste management practices are conducted in a manner which protects public health and the environment; (5) requiring that hazardous waste be properly managed at first to reduce the need for corrective action at a future date; (6) minimizing the generation and land disposal of hazardous waste by encouraging process substitution, materials recovery, properly conducted recycling and reuse, and treatment; (7) establishing a viable federal-state partnership to carry out the purposes of this act and insuring that

the administrator will place a high priority on assisting and cooperating with state programs; (8) providing for the promulgation of guidelines for solid waste collection, transport, separation, recovery, and disposal practices and systems; (9) promoting a national research and development program for improved solid waste management and resource conservation techniques, more effective organizational arrangements, and new ways and environmentally safe disposal of nonrecoverable residues; (10) promoting the demonstration, construction, and application of solid waste management, resource recovery, and resource conservation systems which preserve and enhance the quality of air, water, and land resources; and (11) establishing a cooperative effort among the federal, state, and local governments and private enterprise in order to recover valuable materials and energy from solid waste. CDOT must dispose of all solid wastes in accordance with SWDA requirements. The administrative agency for the SWDA is the EPA.

TOXIC SUBSTANCE CONTROL ACT, PL 94-469, 1976

The 1986 Toxic Substances Control Act (TSCA) was designed as a "catch-all" to close loopholes in environmental protection and chemical manufacture and use laws. The law controls the chemical at its source before it is dispersed into the environment (where environmental protection laws are employed). Excluded from coverage under TSCA are food, food additives, drugs, and cosmetics regulated under the Federal Food, Drug, and Cosmetics Act; pesticides regulated under FIFRA; and nuclear materials regulated by the Atomic Energy Act. Other federal laws control the release of pollutants into the environment or workplace. However, it is very difficult to monitor and set emission standards on substances that only enter the environment in very small amounts. It was recognized that some substances had to be controlled before they were dispersed into the environment. Chlorofluorocarbons (CFCs) used as propellants in spray cans demonstrate this need. When released, CFCs are so stable that they do not react with anything until they diffuse upward to the stratosphere; however, once there they can be decomposed by ultraviolet radiation and enter into a chain reaction which destroys ozone molecules. Ozone depletion would allow more solar ultraviolet light through and could increase the incidence of skin cancer as well as affect climatic changes. Since chlorofluorocarbons are not classified as air pollutants and pose no hazard in the workplace, no means existed for regulating their use. A need to control toxic substances at the point of manufacture was identified by Congress in passing TSCA. The law specifically bans the manufacture of polychlorinated biphenyls (PCB). Chemical manufacturers and importers must provide the EPA a Premanufacture Notice (PMN) and provide health and environmental effects data at least 90 days prior to the manufacture and sale of any chemical. The EPA can approve the chemical, request further testing, condition the manufacture and sale of the chemical, or prohibit its manufacture. The law is a risk/benefit-balancing act similar to FIFRA. The EPA is required to consider the benefits of a substance to society's economic and social well being, the risks posed by alternative substances and the possible health or economic problems that could result from regulation of a substance. TSCA is unique in that it is designed as a gap-filling law. The EPA defers to other agencies for action if those agencies having statutory authority under another law are dealing with identified problems. When the EPA has sufficient authority under another law (e.g., CAA, CWA, RCRA, etc.), the agency is directed to the other law rather than the gap-filling TSCA. Therefore, CDOT is not directly regulated under TSCA because it is not involved in the production of chemicals; other federal laws control the release of pollutants into the environment and thereby have authority over CDOT activities. The administrative agency for TSCA is the EPA.

WILD AND SCENIC RIVERS ACT, PL 90-542, 1968

The Wild and Scenic Rivers Act (WSRA) states that certain U.S. rivers which, with their immediate environment, possess outstandingly remarkable scenic, recreational, geological, fish and wildlife, historical, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. It was declared that the established national policy of dam construction and other work at appropriate sections of U.S. rivers should be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes. The administrative agency for the WSRA is the National Park Service.

III. METHODS OF VEGETATION MANAGEMENT

Six strategies are available for managing vegetation in highway right-of-ways. Preventative measures are the first method; mechanical, chemical, biological, and cultural are the four treatment methods available. The final strategy is an integrated vegetation management plan, employing combinations of the above methods that will provide a desired combination of cost and control while complying with state noxious weed laws. The following sections describe the preventative measures available and the four treatment methods.

PREVENTATIVE MEASURES

Prevention is the procedure utilized to keep previously uninfected areas from developing a problem. This would involve good stewardship and public education. The purpose of this approach is to encourage and provide assistance to producers to control the spread of target undesirable plants. Education and awareness programs are designed and implemented with the aim of creating an environmental ethic among citizens that would stress the need to keep public and private lands free of noxious weeds and avoid actions that would result in conditions that cause noxious weed invasions such as overgrazing or not using certified weed-free hay and mulch.

MECHANICAL

Mechanical controls are those methodologies or management practices that physically disrupt plant growth, including but not limited to tilling, mowing, flooding, mulching, hand-pulling, and hoeing. Mechanical control methods can involve either large machinery or manual techniques which employ both powered and non-powered hand tools. Refer to the expanded coverage in Section V for detailed information.

CHEMICAL

The chemical treatment method involves application of herbicides or plant growth regulators to disrupt the growth of undesirable vegetation. Selective herbicides are used to control specific plants and nonselective herbicides are used to control all plant species and are usually used in the vegetation free-zone (Zone 1) of the roadway. Refer to the expanded coverage in Section VI for detailed information.

BIOLOGICAL

The biological treatment method uses a biological agent (such as an insect or plant disease) to suppress a specific plant species population. The biological agent is matched with a plant species which it is dependent upon for survival. Biological control usually does not totally eradicate the undesirable plants, but will diminish plant populations to a level where the plant is no longer a serious problem or to where it can be more easily managed in combination with other treatment methods. This method affects host plant species on a local basis, which includes areas off of the highway right-of-way.

CULTURAL

The cultural treatment method includes those methodologies or management practices conducted to favor the growth of desirable plants over undesirable plants, including but not limited to maintaining an optimum fertility and plant moisture status in an area, planting at optimum density, spatial arrangement in an area, and planting species most suited to an area. Growing conditions for desirable plants can be improved by adding organic materials to the soil, liming, using fertilizers, and irrigating. Proper selection of planting stock is important to insure vegetative competitiveness. Promoting healthy desirable plant communities produces plants that can resist invasion by undesirable plants as well as disease and insect damage. Often activities such as mowing and application of herbicides are used to promote the growth of desirable species and, therefore, are technically cultural methods. However, the delineation between chemical and mechanical methods that are used to enhance growth and those which are not would be extremely difficult. For that reason a more narrow view of cultural methods which does not include mechanical and chemical applications is used here.

CONTROL AND MAINTENANCE ZONES

Figure 1 shows the zones used to identify the roadside areas for various levels of control and maintenance. These zones were developed and will be used to standardize terminology for roadsides.

Zone 1: Provided for traffic control installations and clear zone for motorist safety. This area will receive higher priority for vegetation control.

Zone 2: Generally, the slope area will provide for surface drainage. Will require some maintenance to maintain drainage, erosion control and traffic safety.

Zone 3: Generally, may require little or no maintenance. This area will primarily be left as is. Some noxious weed control may be needed. Utility accommodation, roadside cut embankment or major fill-slope section. Natural waterways will all fall into this zone.

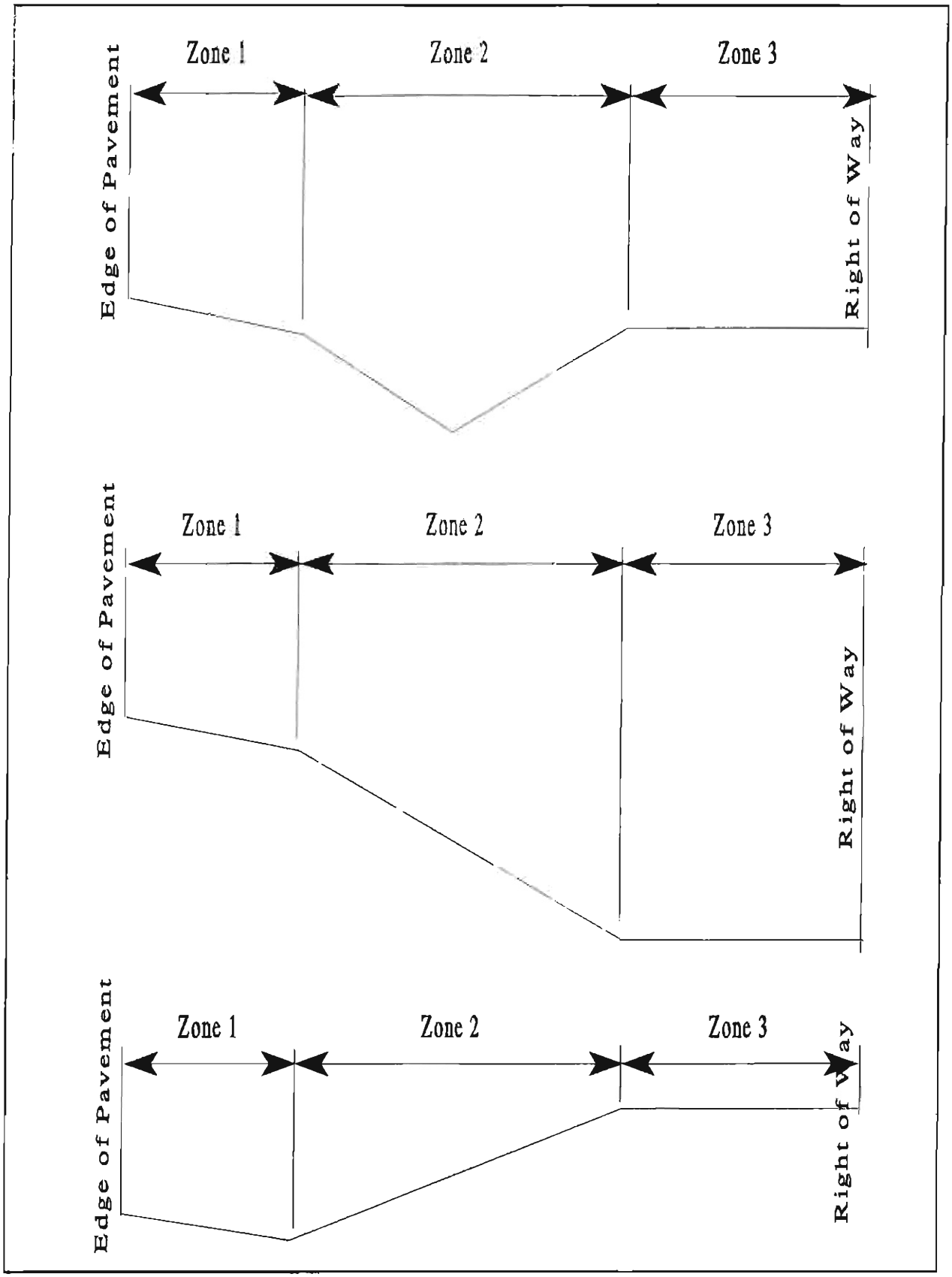

Figure 1. Established Right-of-Way Control and Maintenance Zones.

IV. DETERMINING LEVELS OF VEGETATION MANAGEMENT[2]

The following section provides a categorization of state and county highways based on traffic volume and adjacent property use and describes management practices for each category.

PURPOSE OF THE LEVELS

To aid maintenance planners and workers, the Colorado Department of Transportation has established four levels of vegetation management. Each level sets forth a special set of guidelines for vegetation management based generally on average daily traffic (ADT) and the level of development of the adjacent property. The level of vegetation management will be determined by the Section Superintendant for each segment of state maintained right-of-way within their district by considering other factors such as land used, the types of resources present in the right-of-way, or other special circumstances. A color has been assigned to represent each level of vegetation management as shown in Table 1.

Table 1. Determining Levels of Vegetation Management.

If the ADT is...	And the surrounding property use is...	Then the level is...	Color
Varied	Developed urban (residential, commercial, or services)	1	Red
10,000 and above	Partially developed urban or rural	2	Blue
3,000 to 10,000	Rural (moderately maintained interstate, US and high-volume state highways, and high-volume county roads)	3	Yellow
0 to 3,000	Rural (low maintenance areas: low volume state highways and county roads)	4	Green
NA	Protected Natural Resources (i.e., wetlands, endangered or threatened species habitats)	5	Orange

DISTRICT MAPS

Each District Maintenance Manager will color-code a standard district map to show the appropriate level of vegetation management for each section of state maintained roadway using the colors shown for each level in the preceding table and taking into account the natural resources that are found within these sections. The map will serve as a management tool and should be updated as traffic conditions and surrounding property use change. A current duplicate copy of the color coded map should be on file with the Construction and Maintenance Division of CDOT and in Headquarters, State Maintenance Office for review and reference.

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[2] The levels of vegetation management and the applicable control methods used by the Colorado Department of Transportation have been adopted from the Texas Department of Transportation *Roadside Vegetation Management, a Volume of the Infrastructure Maintenance Manual*, November, 1993.

GUIDELINES FOR LEVELS OF VEGETATION MANAGEMENT

Vegetation management extends from the shoulder of the roadway to the right-of-way limits and also includes the median. Roadside landscaping and vegetation control shall refer to the maintenance treatment given any vegetation, either native or planted, within the limits of the right-of-way. It will include such activities as mowing, brush control, noxious weed control, soil sterilization, tree pruning, planting, thinning, seeding and other related items to enhance the beauty of our highways. The following sections define the integrated vegetation management and control plans recommended for each maintenance level. The recommended control methods discussed herein pertain to right-of-way vegetation in general and the overall highway appearance. Undesirable plants and noxious weeds specifically should be managed on a case-by-case basis and the optional control methods for them are discussed in detail in Section VIII of this manual.

LEVEL ONE

The criteria for Level One vegetation management is summarized as follows:

Average Daily Traffic:	VARIED (This level is determined solely by surrounding property use)
Surrounding Property Use:	DEVELOPED URBAN ONLY (residential, commercial, or services development - including right-of-ways within small cities, towns, and villages)
Indicated Color on Map:	RED

Vegetation management on roadways designated as *Level One* should be conducted according to the following guidelines:

Mowing and Trimming

1. Use frequent full width mowing for developed areas to control the vegetation so as to present a pleasing appearance, curb weed growth and maintain sight distance and visibility of structures. Shoulder swath mowing is to be performed in Zone 1, 2 and/or 3. These areas should be mowed as often as necessary for maximum safety, appearance and conformance with height standards. Consider swath mowing for safety instead of full width mowing in wide right-of-ways. Mowing should be performed in accordance with municipal maintenance agreements where applicable.

2. Set a cutting height of eight to twelve inches (20 to 30 cm).

   NOTE: A minimum of eight inches (20 cm) mowing height will reduce mower-thrown objects and since mowing weakens vegetation and actually reduces the root system of grasses and companion plants, increasing height of cut effectively improves cover and reduces erosion.

3. Mechanically trim behind curbs where appropriate.

Herbicide Use

Chemically treat pavement edges, signs, riprap, delineators, guardrail, etc.

Ornamental Plantings

1. Remove all dead ornamental plants, limbs or branches as soon as possible and replace with appropriate plants as soon as practical.

   NOTE: Landscape plantings and the preservation of selected turf vegetation on the roadside assist in controlling erosion on cut and fill slopes, abate noise, and control weeds. In addition, ornamental plantings add beauty to roadsides.

2. Expand ornamental plantings on a gradual basis to ensure proper plant establishment with available maintenance personnel.

Erosion Control

Implement erosion control measures as necessary (slope stabilization, seeding, mulching, etc.). See the Soil Conservation Service, Colorado State University, and CDOT's "Erosion Control and Stormwater Quality Guide" for further information on recommended erosion control measures.

Wildflowers

In areas where full width mowing will be necessary, it shall be deferred until the early spring flowers have matured seeds. In most areas, this will be approximately four weeks after the blooms fade. There may be other wild flowers in the area that will bloom later and should not be mowed. During this period of wild flower preservation, mowing should be limited to a single pass of the mower adjacent to the pavement for safety (Zone 1). Good wildflower areas should have one full width mowing in the fall.

NOTE: Narrow medians, narrow outer separations, and areas adjacent to manicured private property are inappropriate for wildflower propagation.

LEVEL TWO

The criteria for Level Two vegetation management is summarized as follows:

Average Daily Traffic:	10,000 AND ABOVE
Surrounding Property Use:	PARTIALLY DEVELOPED URBAN OR RURAL
Indicated Color on Map:	BLUE

Vegetation management on roadways designated as *Level Two* should be conducted according to the following guidelines:

Mowing and Trimming

1. Mowing will be confined to Zones 1 and 2 shoulders and slopes on all highways and the narrow medians on four lane highways until after the first of July to protect nesting along fence rights-of-way and barrow pits for game birds. Perform swath mowing only where necessary during wildflower season. Perform subsequent swath mowings as necessary (a minimum of two swaths is recommended). Perform one full-width mowing in late fall.

   NOTE: During high rainfall periods, rapid vegetative growth may require additional strip and spot mowing for safety and to facilitate drainage.

2. Set cutting height no lower than eight inches (20 cm) to leave some residual cover for strong regeneration of native grasses and cover for wildlife.

3. Mechanically trim where appropriate.

Herbicide Use

1. Use chemical overspray or ropewick applicators to control tall grasses and/or other pest plants at least 10 days prior to mowing.

2. Chemically treat pavement edges, paved medians, signs, riprap, delineators, guardrail, etc.

3. Avoid herbicide use in wetlands and aquatic areas.

Ornamental Plantings

Remove all dead ornamental plants as soon as possible and replace with appropriate plants as soon as practical.

Erosion Control

Implement erosion control measures as necessary (slope stabilization, seeding, mulching). See CDOT's "Erosion Control and Stormwater Quality Guide" for further information.

Wildflowers

Mowing shall be deferred until the early spring flowers have matured seeds. In most areas, this will be approximately four weeks after the blooms fade. There may be other wild flowers in the area that will bloom later and should not be mowed. During this period of wild flower preservation, mowing should be limited to a single pass of the mower adjacent to the pavement for safety. Good wildflower areas should have one full width mowing in the fall.

LEVEL THREE

The criteria for Level Three vegetation management is summarized as follows:

Average Daily Traffic:	3,000 TO 10,000
Surrounding Property Use:	RURAL
Indicated Color on Map:	YELLOW

Vegetation management on roadways designated as *Level Three* should be conducted according to the following guidelines:

Mowing and Trimming

1. Normally perform strip mowing only as needed for safety during wildflower season and throughout the April 15 through August 1 wildlife nesting and rearing season (a minimum of one swath is recommended). Perform spot mowings as necessary.

   NOTE: During high rainfall periods, rapid vegetative growth may require additional strip and spot mowing for safety and to facilitate drainage.

2. Set cutting height no lower than eight inches (20 cm) to:

   - ensure strong regeneration of native grasses,
   - provide erect residual cover for the following year's early nesters,
   - provide roosting and escape cover for wildlife, and
   - facilitate drainage and brush control.

3. Establish non-mow areas where appropriate (slopes, wide rights-of-way, large interchanges, etc.) to allow for maximum reseeding and vigor of native grasses, forbs, legumes, and wildflowers and to provide for almost continuous nesting use from spring until late summer.

4. Mechanically trim where appropriate.

Herbicide Use

1. Use chemical overspray or ropewick applicators to control tall grasses and/or other pest plants at least 10 days prior to mowing.

2. Chemically treat pavement edges, paved medians, signs, riprap, delineators, guardrail, etc.

3. Avoid herbicide use in wetlands and aquatic areas.

Ornamental Plantings

Remove all dead ornamental plants as soon as possible and replace with appropriate plants as soon as practical, using locally adopted native tree, shrub, and brush species indigenous to the ecological region.

Erosion Control

Implement erosion control measures as necessary (slope stabilization, seeding, mulching, etc.). See CDOT's "Erosion Control and Stormwater Quality Guide" for further information.

Wildlife Habitat and Native Plant Conservation

Avoid, minimize and delay mowing activities to promote:

- continued propagation of native seed sources across the state,
- ground cover for erosion control, and
- nesting and escape cover for many forms of wildlife.

Wildflowers

Mowing shall be deferred until the wildflowers have matured seeds. In most areas, this will be approximately four weeks after the blooms fade.

LEVEL FOUR

The criteria for Level Four vegetation management is summarized as follows:

Average Daily Traffic:	0 TO 3,000
Surrounding Property Use:	RURAL
Indicated Color on Map:	GREEN

Vegetation management on roadways designated as *Level Four* should be conducted according to the following guidelines:

Mowing and Trimming

1. Perform spot and swath mowing as needed for safety (a minimum of one swath is recommended).

   NOTE: In high rainfall areas, rapid vegetative growth may require additional strip and spot mowing for safety and to facilitate drainage.

2. Set cutting height no lower than eight inches (20 cm) to:

   - ensure strong regeneration of native grasses,
   - provide erect residual cover for the following year's early nesters,
   - provide roosting and escape cover for wildlife, and
   - facilitate drainage and brush control.

3. Establish non-mow areas where appropriate (slopes, wide right-of-ways, large interchanges, etc.). A slope with a 3:1 ratio is considered the maximum angle of safety for mowers, therefore, any slope with a 3:1 ratio or greater should not be mowed.

4. Mechanically trim where appropriate.

Herbicide Use

1. Use chemical overspray or ropewick applicators to control tall grasses and/or other pest plants at least 10 days prior to mowing.

2. Chemically treat pavement edges, paved medians, signs, riprap, delineators, guardrail, etc.

3. Avoid herbicide use in wetlands and aquatic areas.

Ornamental Plantings

Remove all dead ornamental plants as soon as possible and replace with appropriate plants as soon as practical, using locally adopted native tree, shrub, and brush species indigenous to the ecological region.

Erosion Control

Implement erosion control measures as necessary (slope stabilization, seeding, mulching, etc.). See CDOT's "Erosion Control and Stormwater Quality Guide" for further information.

Wildlife Habitat and Native Plant Conservation

Avoid, minimize and delay mowing activities to promote:

- continued propagation of native seed sources across the state,
- ground cover for erosion control, and
- nesting and escape cover for many forms of wildlife.

LEVEL FIVE

The criteria for Level Five vegetation management is summarized as follows:

Average Daily Traffic:	NOT APPLICABLE
Property Description:	PROTECTED NATURAL RESOURCES
Indicated Color on Map:	ORANGE

A *Level Five* maintenance zone can include, but is not limited to, wetlands, endangered or threatened species habitats and archaeological sites. Vegetation management should be minimized on areas designated as Level Five maintenance zones. Before maintenance activities are performed in these areas, a CDOT Environmental Specialist should be consulted.

SPECIAL SITUATIONS

Grass Establishment

In areas of new construction or anywhere newly seeded, sprigged, plugged, or turfed right-of-way is being established, frequent mowing may be necessary to reduce competition from weeds and noxious grasses. However, native grasses must be managed somewhat differently than the more conventional introduced species like fescue and bermuda. Watering requirements depend upon the season, climate, soil, variety of grass and drainage. Blue and turf grass require fertilizing at frequent intervals and varying quantities and may not be appropriate for Colorado.

Wetland creation sites should only be mowed at the direction of a CDOT Wetland Biologist regardless of the weed population.

Native Grasses

To avoid severely weakening a stand of native grasses, it is important that they not be cut too short or too often. Frequent mowing of native grasses would allow noxious weeds to invade. Once established, native warm season grasses should not be cut lower than eight inches.

ROADSIDE APPURTENANCES

Roadside appurtenances, which include road signs, guardrail, and other safety features, require special management considerations. The vegetation around these appurtenances must be managed to ensure that they remain safe and functional. Selective removal and cutting are the two best management techniques for these features.

1. The vegetation around guard rails shall be cleared away so motorists can positively locate them. Vegetation treated with a non-selective herbicide that results in exposed gravel (as constructed) is the most effective tool.

2. Woody vegetation must be kept out of areas where clear vision is required for safety and away from directional signs so motorists have an unobstructed view. If the clear zone is properly maintained, the signs should be readily in view.

3. Drainage structures, bridges and culverts and outfalls, must be kept clear of debris to allow for proper drainage. This will also ensure they are kept in full view for motorists and maintenance personnel. A non-selective herbicide may be used if the original gravel as constructed is exposed. If bare ground would be exposed, then cutting is the appropriate method.

DESIGN AND CONSTRUCTION

The Staff Landscape Architect or consulting Landscape Architect shall design a seed mixture, planting scheme, and erosion control features to be included in new construction plans. The landscaping and seeding plans shall be based on the elevation, soils, availability of water, native plant species and the visual characteristics of the corridor. The availability of water is the primary concern to the establishment and maintenance of roadside vegetation in Colorado. For this reason, the Highway Commission established a policy in 1977 which directs the use of native or dryland adaptable plant materials on future Department landscaping projects. The chief objectives of the seeding and landscaping plan is to provide for the successful establishment of plants which will prevent erosion and will beautify the roadside environment with a minimum of maintenance effort and expense. Seeding and landscaping planning for most highway corridors and climate zones have been developed for the state. Special consideration must be given to preserving existing wetlands and/or replacing wetlands. Normal roadside plants can very often compete or invade wetland complexes which require the presence of special plant species to function properly. Consideration must also be given to the blowing snow problem frequently occurring during the winter.

The following is a list of design objectives for landscaping and seeding plans:

1. The Maintenance Section should be represented at the project Field Inspection Review (FIR) and Final Office Review (FOR);

2. The Clearing and Grubbing Plan should be developed in coordination with the input of the Landscape Architect, Staff Biologist, Maintenance Section representative and the Engineer in the field;

3. During the environmental clearance process, commitments for wetland creation and riparian replacement mostly will require special plantings and possibly special maintenance. The design should be as maintenance free as possible. A Maintenance Section Representative should be informed of those needs to insure the site is successfully managed. The Environmental Section should show no-mow and no-spray areas;

4. Wherever possible, consideration should be given to flattening cut slopes in order to minimize problems of blowing snow (See "Blowing and Drifting Snow Control Measures," Dr. Ron Tabler, SHRP Research Project Report, 1993.);

5. Guidelines for implementation of the Xeriscape concept should be developed on all state highway corridors;

6. Maintenance work in wetlands or other aquatic environments may require a state and/or local permit. It will be necessary to contact the Regional Environmental Manager prior to the seeding activity.

7. Planting of shrubs and trees should:

- be placed in accordance with the clear zone management concept of this policy;
- provide for a pleasing aesthetic view;
- not be planted where roadway may be shaded during winter;
- be far enough away from the driving lane, so as not to interfere with sight distance or to pose a hazard to the motorist;
- be planted where moisture zones exist for improved survival;
- provide a conservation oriented low gallonage irrigation system which will allow for ease of watering for initial establishment of plants where required;
- encourage the planting of native species;
- encourage the development of living snow fences; and
- remove trees when they are very small (before they mature) in Zone 1.

7. Seed mixtures should:

- be consistent with the zone management concept of this policy; and
- reflect adjacent land uses and vegetation types such as for wetlands, farm crops, and urban areas utilizing native species to the fullest extent possible.

V. MECHANICAL OPERATIONS

The Mechanical Operations section of this document provides a detailed description of the available mechanical management techniques, including hand labor, mowers and brush cutters, and some special situations and precautions.

Mechanical methods can involve a variety of techniques including tilling, mowing, flooding, mulching, handpulling, and hoeing. The use of mechanical equipment may be limited in steep terrain and may require flaggers and traffic control vehicles in addition to equipment operators. The following sections discuss hand labor and the types of mechanical equipment available for vegetation control on highway rights-of-way.

Some mechanical operations, if done in wetlands, may require a 404 permit and an SB40 permit as well.

HAND LABOR

Hand labor involves individuals using mechanical tools to prune or remove undesirable brush and trees. Individual plants can be selected and treated or removed using shovels, saws, or other devices. This method is very selective and usually has little negative impact on the environment.

However, hand labor is the most selective, most expensive and least cost effective means of vegetation control. This tool is only as effective as the laborer's and supervisor's experience or knowledge about the objective of the assigned vegetation management technique.

Two types of manual cutting are available: cutting of large woody stems of trees or shrubs, and cutting of herbaceous biomass and small stems of woody seedlings and vines.

Cutting Large Woody Stems

Chain saws, handsaws, axes, and pruning tools are used to cut large woody stems and limbs. Such cutting is used in highway right-of-way vegetation control to:

1. Remove individual trees and limbs from physical encroachment on the shoulder;

2. Remove individual trees and shrubs from sight lines important for line-of-sight visibility on curves, on hills, and at intersections;

3. Remove individual trees and large shrubs with stems greater than 4 inches (approximately 10 cm) diameter from vehicle recovery areas;

4. Remove individual hazard trees or limbs in danger of falling on roadways or in rest areas; and

5. Remove shading canopy in locations where snow and ice buildup is hazardous.

Manual cutting is effective for eradication of conifer trees. Most hardwood tree and shrub species will resprout when cut, requiring either frequent recutting to control height growth or treatment of the cut surface with an herbicide to achieve full eradication. Chain saws, as with all power equipment, cannot be used on dry vegetation during summer months and fall months because of risk of fire ignition. While spark arrestors reduce this risk, they do not eliminate it.

Cutting Herbaceous Biomass and Small Woody Seedlings

Manual tools used to cut tall-growing herbaceous plants and small woody seedlings and vines include stringcutters (e.g. weed eaters), small power mowers, machetes, weed whips, and scythes. These tools are used to clear target plants from safety hardware bases, drainage ditches and culvert inlets and outlets, landscape plantings, and sight lines across unlandscaped rights-of-way.

As with mechanical mowing, cutting of target plants must often be repeated more than once per year to meet vegetation control needs. In drier areas where herbaceous vegetation becomes senescent in summer, a single late-spring cutting may suffice.

Hand Pulling and Hoeing

Hand pulling and hoeing is effective when roots of small seedlings or small herbaceous plants can be removed intact to achieve permanent eradication. Hand pulling and hoeing can be used effectively in right-of-way management when individual target plants are scattered within relatively intact stands of preferred vegetation, such as in the following areas:

1. Safety hardware bases surrounded generally by low-growing, perennially green vegetation but with scattered seedlings of tall-growing species that would block visibility;

2. Drainage ditches occupied generally by low-growing vegetation that does not impede drainage but contains scattered seedlings of tall-growing trees or shrubs;

3. Nonlandscaped rights-of-way occupied generally by preferred native vegetation that does not block line-of-sight visibility but contains scattered seedlings of tall-growing trees or shrubs that could block visibility;

4. Nonlandscaped rights-of-way occupied generally by native vegetation but containing scattered noxious weeds; and

5. Landscape plantings containing scattered seedlings of undesired species.

Woody seedlings beyond the first year of growth are difficult to remove by hand pulling or hoeing. Hand pulling and hoeing are of limited effectiveness on plants with extensive root systems from which sprouting can occur.

MOWERS AND BRUSH CUTTERS

Mowing is the traditional management tool resulting in a uniform turf appearance that many individuals find visually pleasing. Mowing controls the growth and reproduction of undesirable woody plants, annual, biennial, perennials, and noxious weeds.

The timing of mowing is very important. Noxious weeds should be mowed before they flower and during periods of low energy reserves, thereby reducing their ability to propagate. Annual weeds should be mowed monthly, starting in spring, to keep them from dominating a stand. Mowing turf areas every three to five years is an effective means of removing woody vegetation before it gets too large to handle cost effectively.

Mowing has been an effective tool for controlling unwanted herbaceous vegetation with minimal environmental damage. Mowing operations should involve supervisors, trained operators and well maintained equipment.

However, research has shown that the general health and vigor of turfgrasses are affected by both mowing height and frequency. Repeated mowings (more than three a season) at a height shorter than three inches, significantly retards root growth, leaf and dry matter production and the amount of carbohydrates synthesized and stored. Though mowing is detrimental to turfgrasses, they have tolerance of and adaption to this management practice.

Goals of Mowing

The vegetation management goals of mowing are:

1. To establish and maintain clear vision areas at intersections and on the inside of curves, to establish and maintain a clear zone on the sides of the roadway free of woody plant growth, and to provide an area sufficiently clear of plant growth so that drivers can see animals on the roadside.

2. To provide vegetation of an intermediate height in order to affect a smooth transition from the roadway to the taller unmowed vegetation beyond, to eliminate rank growth near the shoulder, and to provide vegetation for the motorist's pleasure.

3. To preserve native vegetation and to encourage its regeneration.

4. To provide habitat for wildlife beyond the clear zone.

5. To help control noxious weeds.

6. To mow after grass has gone to seed.

Light-Duty Mowers

Light-duty mowers are used to control herbaceous vegetation. Both flail and rotary sickle bar cutting mechanisms are used. Flails are metal blades attached to a rotating shaft. Sickle bars consist of knives riveted to a bar that moves horizontally back and forth through a set of heads. Light-duty mowers are mounted on or pulled by tractors and are used only on flat and gently sloping, open terrain. Specialized flail mowers with cutting heads mounted on hydraulic arms are used to extend up to 20 feet (6.1 m) for mowing steep slopes, the sides of ditches, or other hard-to-reach areas.

Light-duty mowing can remove plant biomass above the height set for the cutting mechanism and, therefore, should be selected for low-growing species adapted to periodic removal of top growth, such as grasses. Mowing frequency, height, and timing varies with species or vegetation types. This factor can be used to promote certain species and vegetation types desired.

Light-duty mowing is effective in right-of-way treatment sites where preferred vegetation is low-growing (i.e., less than 6 inches (15 cm) tall) and when access by mechanized equipment is possible. On highway rights-of-way, these sites may include:

1. Clear strips where species present will not degrade the road edge;

2. Drainage ditches with gently sloping sides accessible to mowing equipment;

3. Drainage ditches that can be reached by mowing heads mounted on hydraulic arms;

4. Nonlandscaped areas supporting herbaceous vegetation; and

5. Areas landscaped with turfgrass, such as freeway interchanges.

In areas occupied by annual vegetation that dies and dries up each summer, mowing is most effective at the end of the annual growth cycle prior to the setting of seed (late spring). This timing removes most plant biomass and minimizes regrowth. The period available for this type of mowing may be limited to several weeks. If mowing is done earlier, multiple mowings may be required. Mechanical mowing cannot be performed in summer after annual plants have dried in fire hazard areas, because of the risk of igniting standing biomass by sparks from mufflers and from metal cutting mechanisms hitting rocks.

On sites where seedlings of incompatible species of trees or shrubs that resprout are present, mowing will cause increased density and lateral expansion of the sprouting species. Increased site occupancy by incompatible species will be at the expense of preferred species.

Light-duty mowing cannot meet control needs in pavement cracks. Pavement cracks require the removal of all plant parts, including roots. In some locations, mowing in clear strips may not remove stubble or thatch that could interfere with water passage off the pavement or could remain as a fire hazard. Mowing around shoulder hardware bases is hampered by the difficulties in maneuvering mowing heads close to hardware bases (e.g., underneath guardrails and around signposts).

Heavy-Duty Brush Cutters

Heavy-duty mowers and brush cutters are used to control woody vegetation with trunk diameters up to six inches (15 cm). Heavy-duty rotary mowers have one or more rotating blades similar to those in home-use power lawn mowers. Brush cutters using a hammer-type mechanism to cut and tear branches are also used. As with flail mowers, cutting heads can be attached to an extendable hydraulic arm.

Heavy-duty mowing and brush cutting is performed primarily for drainage ditch cleaning and on nonlandscaped right-of-ways for line-of-sight visibility (e.g., on cutslopes). Heavy-duty mowing using cutting heads on a hydraulic arm can be used to control woody vegetation on clear strips and around safety hardware. Heavy-duty equipment is used on sites where growth of woody species of shrubs, trees, and vines is so rapid that it cannot be controlled using light-duty equipment.

Heavy-duty brush cutting is inappropriate for controlling woody species that resprout rapidly from cut or broken stems or from roots. Use of such equipment can convert a mixed stand of sprouting and nonsprouting species to a dense thicket of sprouting species. Annual retreatment is necessary where sprouting regrowth is rapid. Such action may require a 404 and/or SB40 permit, and therefore it is necessary to contact the Regional Environmental Manager.

Full Width Mowing

Full width mowing includes all unpaved right-of-way, except for designated non-mow areas where the grade is too steep or the area is covered with desirable plants. The frequency of full width mowing for a given roadway will depend on the level of maintenance assigned to that roadway and its existing plant communities and wildlife habitats.

Swath Mowing

Mowing the area 5 to 15 feet (1.5 to 4.6 m) from the edge of the shoulder (whether paved or unpaved) is called swath mowing. A five foot strip (1.5 m) may be adequate on highways with paved shoulders. In addition to mowing the strip along the shoulder, all strip mowing operations will include:

- mowing from the pavement edge or shoulder to the right-of-way line next to developed areas (cemeteries, schools, churches, private dwellings, community centers, etc.);
- all mowing necessary to maintain adequate sight distances for intersections, private entrances, curves, off-ramps, on-ramps, signs, delineators, and other appurtenances;
- mowing around all appurtenances (signs, delineators guardrail, culvert headwalls, etc.) that are within the designated strip width;
- mowing the entire width of narrow medians and outer separations;

- mowing full width, from right-of-way to right-of-way for drainage where appropriate;

- mowing a smooth and gradual transition that will blend the designated strip width with other areas that require a greater or lesser mowing width.

Spot Mowing

Spot mowing will be performed when and where necessary to maintain adequate sight distances for inside curves, off-ramps, on-ramps, intersections, private entrances, signs, delineators, and other appurtenances and/or to control certain weed species. Spot mowing is generally performed when safety needs arise between scheduled swath mowing cycles. This may include spot mowing of noxious weeds before they go to seed if no other control measure is available.

Transitions

Wherever two areas requiring different mowing widths are adjacent, a smooth and gradual transition should be achieved to visually blend the two areas. For example, a transition would be required between: (1) the designated strip mowing width and the greater width required around a sign; (2) an area that is mowed full width and non-mow area; (3) the designated strip mowing width and the extra width required to maintain sight distances at a curve, driveway, or intersection. The rate of transition should be gradual enough to allow adequate sight distances for prevailing traffic conditions and also provide a smooth visual effect.

SPECIAL SITUATIONS

Grading

Grading is the use of a rigid blade to shape the soil surface and to remove vegetation. Shoulder pulling is grading performed to restore lateral support by replacing soil eroded from road edges.

Grading is useful in sites accessible to heavy equipment where removal of all plants is desirable and disturbance of the soil surface is acceptable. Although grading is effective in removing vegetation, graded soils are easily eroded by rainfall or surface runoff until new vegetation is established. Soils that have been disturbed by grading are often rapidly recolonized by vegetation, requiring frequent retreatment to maintain a bare-soil condition. Soil exposed by grading can easily wash or blow away, contributing to water turbidity and airborne dust. Vegetation and soil removed by grading must be disposed of, requiring additional labor and expense.

Because of these considerations, grading to remove vegetation is only useful when reshaping the soil surface is a primary need, for example, in shoulder pulling or reshaping of drainage ditches.

Disking

Disking uses vertically mounted round metal plates to slice through and turn over soil. Disks are mounted on or pulled by tractors over flat or gently sloping terrain. Disking is useful for

destroying existing vegetation in large areas. Disking has some disadvantages similar to those of grading; disked soils are somewhat erodible and are also rapidly recolonized by vegetation.

Rural Medians and Outer Separations

The entire area of rural medians and outer separations should be mowed during spot and strip mowing operations, unless the grade is too steep or the area is covered with trees, shrubs, or other vegetation desirable for wildlife benefit or erosion mitigation. On extremely wide medians and outer separations normally only transition and shoulder strip mowing should be performed. This applies to all divided highways including state, U.S., and interstate highways.

Rural Intersections

During spot and strip mowing operations, the area around rural intersections or interchanges will be mowed as necessary to provide adequate sight distances.

Cut and Fill Sections

Normally, on fill sections, only strip mowing will be necessary. Strip mowing will also be adequate in cut sections; however, at deep cuts, mowing must extend across the ditch line to the beginning or base of the backslope.

Rest Areas and Picnic Areas

Rest areas and picnic areas should be maintained in a lawn-type condition with frequent mowings as may be required.

Litter Pickup

Litter pick up operations should be conducted before mowing operations unless safety concerns dictact that mowing preceed trash pickup. Mowing a littered portion of right-of-way would increase the risk of the mowers striking unseen objects and causing harm to people, machinery, and passing traffic, cause shredding of large pieces of litter, resulting in more time consuming litter pickup operations, and expose more litter to view.

GENERAL PRECAUTIONS

The main purpose of the vegetative cover on the right-of-way is to protect the roadside from erosion. Left unprotected, deterioration would occur, threatening the paved surface of the roadway. Mowing is an important component of roadside vegetation management, but it must be conducted with care to preserve the vegetative cover. Observing the precautions contained in this section will help: (1) ensure efficient and environmentally sound mowing operations; (2) promote wildlife habitats; (3) maintain seed sources for the state's native flora.

Delay Mowing When Soil is Wet

When the soil is wet, delay mowing. Tractor tires cause severe rutting in wet soil. Rutting, especially on slopes, causes erosion and leads to the spread of noxious weeds. Erosion leads to deterioration of the roadside and threatens the paved surface of the roadway.

Avoid Mowing Steep Slopes

Avoid mowing steep slopes (3:1 ratio or steeper), even in urban areas, whenever possible. Mowing steep slopes increases compaction, causes slope failure and rutting, and decreases the vigor of the vegetation. Loss of plant growth results in slope erosion.

> NOTE: If the slope rises one unit for every three horizontal units, then the ratio is three to one (3:1). Therefore, a 2:1 slope would be steeper than a 3:1 slope.

Use Appropriate Cutting Height

Never set mower cutting height lower than eight inches (20 cm). Low cutting (also called "scalping") is undesirable because it: (1) produces stress in the vegetation, especially during dry, hot conditions, resulting in loss of vegetative cover; (2) deprives ground-nesting wildlife of cover; (3) increases the number of objects thrown by mowers.

Avoid Mowing Too Frequently

Avoid mowing too frequently. Without supplemental watering and fertilization, frequent mowing puts undue stress on native grasses. Many noxious weeds and grasses have food storage capacity in a rhizome-root system and can withstand frequent mowings. Frequent mowing may allow unwanted vegetation to dominate and also deprive wildlife of food and cover.

Coordinate Mowing with Grass Seed Production

Effective mowing operations require coordination with seasonal cycles, as well as with other roadside maintenance activities. In late summer and early fall, grasses produce seed-heads. Seed-heads develop very rapidly and, if cut, will regenerate in eight to twelve days. Mowing operations during seed-head production result in wasted time and money. After seed-heads mature in October and November, grasses will become dormant. Mowing after this period will result in a clean right-of-way until spring.

VI. CHEMICAL OPERATIONS

The Chemical Operations section provides an overview of the available chemical management techniques, including types of herbicides, types of control, types of plants to be controlled, and factors contributing to the chemical effectiveness. For more information on the specific herbicides to be used and their application requirements see *The Colorado Weed Control Handbook*.

Herbicide use is regulated by the Environmental Protection Agency and by state agencies acting in conjunction with the EPA. Herbicide manufacturers must pay an annual fee to obtain a registration number for each herbicide they produce. Annual reports on each product must also be submitted, containing information on ingredients and waste products associated with each herbicide. It is the responsibility of the State, working with the EPA, to ensure that no unregistered herbicides will be used along roadways in the state. Applicators and Supervisors must be licensed.

All pesticide products have been classified by the EPA as either general or restricted use. Pesticides that do not ordinarily cause unreasonably adverse effects on the user or the environment are listed as "General-Use". Pesticides that can cause adverse effects on the user or the environment are listed as "Restricted-Use". These products can only be applied by qualified persons as designated by certain applicator certification programs. All label restrictions and guidelines should be followed at all times while handling pesticides. Also, protective clothing should be worn during this process.

TYPES OF HERBICIDES

There are two general categories for herbicides based on how they affect the vegetation:

1. Soil-active (residual) herbicides; and
2. Foliar-applied herbicides.

Both have specific purposes and it is, therefore, important to understand the proper use of each.

Soil-active (residual) herbicides prevent reproductive processes and root growth from occurring. They are applied to the soil and absorbed into the root system. From there, they are translocated throughout the plant, eliminating plant growth. Toxic effects usually appear after a few days. They should be applied shortly before initial plant growth in the latter stages of winter or shortly before growth occurs in the initial stages of spring. Most vegetation can be controlled throughout the entire growing season by using a broad-spectrum, soil-active herbicide.

Foliar-applied herbicides are sprayed directly onto the leaves of the undesirable plant. They are absorbed by the foliage and transported throughout the plant, affecting growth. Toxic effects usually appear within several days. These herbicides have no soil residual activity. Therefore, multiple applications may be required if the initial application is released by the plant before it can totally eliminate plant growth. A combination of herbicides may be required due to vegetative variations.

TYPES OF CONTROL

Normally, soil-active herbicide application produces either complete vegetation control or bare ground. Too much of a chemical will generally produce the latter. Bare ground may be desirable if it is economical and if erosion can be controlled or if plant growth creates a hazardous situation.

Growth regulators are substances that affect one or more factors of the growth process which slows the vegetative growth. These could include, among other factors, cell elongation, seedhead initiation, and water absorption. This will provide extended maintenance time without killing all the vegetation. Growth regulators are usually not hazardous to humans or animals and may only need to be applied one or two times per year. Unfortunately, they can often be costly and, therefore, may be advantageous for selective applications only. Also, they are generally only effective in cooler climates.

Selective weeding uses a herbicide(s) to control certain vegetation without affecting the desired vegetation. It may be applied to the vegetation in either a pre-emergent or post-emergent condition. This is useful for controlling undesirable species interspersed with desirable ones.

Chemical mowing is used when valuable plants are in close proximity to the undesirable vegetation. This is an important procedure for controlling vegetation in and around guardrails, fences, drainage ditches, and landscaped areas. Soil sterilants (chemicals that have a long-term residual toxic activity, thereby preventing new growth of any type of vegetation) are currently being used for "non-mow" areas such as guardrails. However, due to their long-term activity, the use of soil sterilants is discouraged.

TYPES OF PLANTS TO BE CONTROLLED

Plants are generally categorized as annual, biennial, and perennial. This is very important in determining the types of herbicides to be used and the application method. Also, there are several growth conditions which a plant may be exhibiting: active growth or dormancy; seedling or mature plant; budding, fruiting, flowering, or leafing. These must be taken into account when deciding if, when, and where to use herbicides. In general, a younger plant is easier to control than one that is well established.

Annual and biennial plants are produced from seeds. An annual plant completes its life cycle in one year; biennial plants require two years. The seeds produced are usually found near or on the soil surface. Perennial plants survive for longer periods of time due to an extensive root system. They also produce seeds to ensure further growth of the species. Appropriate herbicides and application methods depend on the growth condition of the chosen plants. When perennial plants have become well established, very specific herbicides are generally required for plant control.

SOIL TYPE

The soil type is a very important consideration when using soil-active herbicides. They are more effective in soils with low levels of clay and organic matter due to the decreased adsorption to these particles. In these situations, the application rates can be reduced. When soils are high in

clay and organic matter, the herbicide will adsorb to these particles instead of being translocated through the root system and throughout the plant.

The acidity of the soil can also be an important factor in selecting herbicides. High acidity or alkalinity may increase the rate of decomposition of the herbicides, which may make them inactive.

WEATHER

Containment within the right-of-way is a major concern when using herbicides. Wind can affect the herbicide spray pattern, causing "drift" or airborne movement to off-target areas. This is a potential hazard to sensitive vegetation and aquatic systems in close proximity to the target area. In fact, high winds can carry the herbicide several thousand feet from the intended target.

The drift of a herbicide is also affected by the size of the spray particle, the distance between the spray nozzle and the ground, pressure applied by the application equipment, and chemical vaporization. The effect of the wind can be minimized with a drift control agent. These are often foams or thickeners and are relatively inexpensive. The pressure is a function of the application rate and the particle size. These should be adjusted as necessary.

Certain measures can be taken to control drift:

1. use a drift control agent;
2. use low application pressures;
3. angle the nozzle toward the ground and slightly forward;
4. use the largest possible opening while still conforming to application rates;
5. use less volatile chemical formulations when feasible;
6. spray when wind speed is negigible;
7. do not spray during a temperature inversion; and
8. spray when sensitive weed is mature.

The relative humidity will affect the amount of absorption of the herbicide by the plant. At higher humidities, the plant cuticle and wax layer of the plant leaves are generally thinner than at lower humidities, increasing the rate of herbicide absorption.

Rainfall has a great effect on herbicide use. Applications should not proceed during rainfall or if rain is predicted within six hours. Foliar-applied herbicides will be washed off the leaves before they can be absorbed. Soil-active herbicides will be washed away before they can settle into the soil. These actions may result in damage to vegetation outside the target area. However, soil-active herbicides require water to be effective; they must be in solution before they can be

absorbed into the roots of the plant. But, excessive water may cause the herbicide to leach below the root zone, resulting in ineffective control. Applying herbicides after a rainfall is effective because the rain will have washed away dust particles from foliage and moistened the soil. It is necessary, though, to let the foliage dry because the water remaining on the vegetation may decrease the effectiveness of the herbicide.

Temperature can have a great effect on herbicide application. Herbicides should not be applied when there is snow on the ground or when it is frozen. Also, high temperatures may cause a plant to become dormant and incapable of herbicide absorption.

MIXING AND APPLICATION

Water quality is an important factor influencing herbicidal effectiveness. The two major problems are potential impurities and acidic content. Water impurities can damage the application equipment and can deactivate the herbicide. The water acidity is a factor because some herbicides will decompose under acidic or alkaline conditions and may become inactive. To avoid ineffective mixtures, mix small amounts of the required application to be used in a short period of time. Always use clean water for herbicide mixtures

Proper application is a crucial factor in herbicide treatment. The growth stage of the plant and the weather conditions are the most important factors affecting time of application.

There will be no band spraying in wetlands or other aquatic systems. Only spot spraying of herbicides approved for use in such areas will be allowed.

NOTIFICATION

A recorded message has been established by CDOT listing when and where chemical spraying will be performed. This number can be called by chemical sensitive people or others who wish to receive information on spraying in their area.

RECORD KEEPING

Complete records of all mixing and applications must be kept by herbicide applicators.

CDOT BANNED CHEMICALS

In most cases the specific pesticides used for weed control should be chosen by the designated district personnel and/or the licensed applicator.

VII. ENVIRONMENTAL CONSIDERATIONS

This section provides a general description of the environmental impacts of the various management strategies.

GEOLOGY AND SOILS

Geology and soils are important physical factors in determining slope stability, shoulder drainage, surface erosion, and water quality along Colorado highways. Geology often directly influences right-of-way slope stability. Slope failures, in turn, can affect water quality and, in more severe cases, impact the physical condition of the highway. The relationship between geology, soils, and vegetation on highway rights-of-way is also extremely important. Good vegetative cover protects the function, stability, and condition of soils, while good soil conditions are necessary to maintain healthy vegetative cover and discourage undesirable vegetative growth. Thus, both the physical and biological roadside environment must be evaluated when developing and applying vegetation management techniques.

In the roadside environment, the characteristics of relatively undisturbed, native soils can generally be found in Roadside Management Zone 3. Familiarity with native soils, that in many cases continue to exist in Zone 3, is important, particularly in determining how roadside vegetation management techniques will affect the environment in the different regions. Where soils have been altered to meet highway design specifications (Zone 1) or to meet roadside drainage specifications (Zone 2), most of the preconstruction soil characteristics have been markedly changed. Often, soil materials foreign to the site have been placed in these zones and compacted to meet construction requirements. This condition creates an unnatural and often extremely harsh soil environment in which vegetation must establish and grow.

Soil Erosion

One of the primary objectives in vegetation management along transportation corridors is to minimize accelerated soil erosion. Erosion is defined as the process of detachment and transportation of soil materials by water, gravity, wind, or ice.

Soils within transportation corridors are often severly altered from their natural conditions. The soil surface may be severely compacted or cut bank and side fill slopes may be steeper than would have evolved under natural geologic processes. Thus, these altered areas in the roadside environment have physical soil conditions with high erosion potential. The magnitude of erosion potential, however, is often correlated to the natural erodibility of soils that varies by physiographic region.

Environmental Consequences of Treatment Methods

Chemical Techniques. Chemical treatments for vegetation management generally do not affect the geology or soils along Colorado highway corridors. While improper application of herbicides may indirectly affect soil microorganisms, their controlled use in terms of quantity and timing should ensure no negative impacts on soils and geology. The use of fertilizer for vegetation

establishment and management is particular useful in controlled quantities to supplement the natural soil nutritional capability.

Cultural Techniques. Cultural techniques have no adverse impacts on geology and soils. In general, cultural techniques stabilize surface soils and reduce both the potential for and the impacts of surface erosion and slope failures.

Biological Techniques. Although plant pathogens could alter soil microorganism populations, the effects would most likely be less than detectable levels. Thus, biological control of undesirable vegetation would be considered to have no negative impacts on soils and geology within the State of Colorado.

Mechanical Techniques. Mechanical techniques have the greatest potential to impact soils by causing soil compaction and exposing soil to surface erosion. Soils can be severely compacted by heavy equipment used for mechanical techniques, especially if the soils are wet. Mowing and manual treatment methods generally have a low potential to cause soil erosion because they retain substantial soil cover. Grading, however, creates a high potential for erosion because soil surfaces exposed by this technique can be easily eroded by the action of water or wind.

Mechanical mowing and flailing or chemical destruction of deep-rooted vegetation has the potential to reduce slope stability. If manual control is used very intensely, it could impact soil stability in the same manner.

WATER QUALITY

Protecting water quality is one of the primary reasons for maintaining a healthy vegetation cover in the roadside environment. An understanding of the process in which vegetation affects water movement is important in defining how vegetation management techniques affect water quality.

Surface Waters

Surface water quality may be adversely affected where the soil surface of highway rights-of-way has been disturbed. In addition to eroded soil, highway runoff that carries common pollutants which are a direct result of the highway's operation (as per "Constituents of Highway Runoff," FHWA-RD81, Vols 42-47, FHWA, USDOT, 1981). One effective method to protect surface water quality from these roadside pollutants is to maintain an adequate vegetation cover and permeable soil surface that filters the contaminants in runoff. High volume stormwater runoff, retention, and detention areas are often built to temporarily impound runoff waters and remove contaminants.

Groundwater

The term groundwater is used here to broadly mean all water below the ground surface. Protection of groundwater quality is of concern in roadside vegetation management because of its importance as a resource for public drinking water supplies, irrigation, and industrial uses. The roadside environment may contain a variety of contaminants that can potentially degrade the quality of susceptible underlying aquifers and substantially impact their viability as a resource.

Vegetation is important to groundwater in that it affects the soil storage component of the water balance that can effectively reduce the amount of water available for the recharge of underlying aquifers.

The hydrologic characteristics of the soils and rocks determine the path of pollutants and their rate of movement. Substances dissolved in water move through the most permeable zones with the water, except when they are slowed by sorption. For example, clays and organic matter may sorb trace metals and certain organic pollutants and thereby reduce their concentration as they move through the underground environment.

Use of herbicides along roadways may introduce organic chemicals to the underlying groundwater system. However, several mechanisms tend to prevent or retard the migration of most organic substances from the land surface or soil horizon into deeper groundwater aquifers. These mechanisms include chemical precipitation, chemical degradation, volatilization, biological degradation, biological uptake, and adsorption. Furthermore, many organic substances have extremely low solubility in water. This generally limits appreciable migration of large quantities in groundwater. Unfortunately, solubility constraints may not totally prevent migration at significant concentration levels. Some organic substances have high appreciable solubility in groundwater and can have significant mobility, particularly in sand and gravel.

Stormwater

Major factors influencing amount and rates of stormwater runoff from transportation corridors include:

- Amount and intensity of precipitation;
- Permeability or infiltration capacity of soil;
- Distribution and amount of impervious surface;
- Soil moisture storage capacity;
- Steepness of terrain;
- Type of vegetation or other soil surface cover; and
- Distance and length of slope to a receiving water channel or body.

Highway corridors produce additional storm water because some of these factors have been changed from the original undeveloped conditions. Road surfaces generally prevent infiltration, resulting in increased amounts of storm water runoff. Soils on fill slopes are often compacted to maintain stability, which removes much of their natural infiltration capacity. Additionally, cut and fill slopes are often so steep that even small amounts of rain will be converted to runoff. Vegetation communities on the road margins are often simple compared to natural communities and therefore less able to dissipate the force and impact of falling rain.

Environmental Consequences of Treatment on Waterways and Hydrologic Systems

Hydrologic processes affected by roadside vegetation management include surface water infiltration to aquifers and runoff to streams, lakes, estuaries, and wetlands. The potential impact of vegetation control measures on infiltration and runoff vary with the treatment method used and site-specific environmental and physiographic conditions.

Chemical Techniques. Chemical techniques of vegetation management can have a range of impacts on waterways through changes in the hydrologic regime. Changes in vegetative cover rather than the chemicals themselves have the potential to affect hydrology. The application of highly selective herbicides to remove target species that are a minor component of a well-established stand of roadside vegetation may result in no measurable change in the hydrologic characteristics of the site. Conversely, application of non-selective, soil sterilant herbicides used to remove and maintain Zone 1 free of vegetation may increase erosion and runoff. Chemical application methods that involve driving heavy machinery on the right-of-way may also compact soils, decrease infiltration, and further increase runoff.

Cultural Techniques. Cultural techniques used for vegetation management activities would generally not have an impact on waterways and hydrologic systems. Cultural techniques of establishing vigorous native plant communities often provide a positive benefit to waterways and hydrologic systems by developing more permeable surfaces that reduce storm water runoff. However, the application of fertilizers and other soil amendments used to promote vegetative cover has the potential to contaminate runoff water or leach into groundwater. Fertilizer application rates should be carefully matched to plant uptake rates to reduce the potential for contaminating runoff or groundwater.

Biological Techniques. Biological vegetation control management activities should have no impact on roadside hydrologic systems.

Mechanical Techniques. Mechanical vegetation control using heavy machinery could reduce infiltration by compacting the soil surface while reducing vegetative cover. These two shifts in the hydrologic regime would both contribute to increased runoff. Use of machinery on wet soils and steep slopes should be avoided to reduce the impact on infiltration rates and erosion. Of all vegetation control techniques, mechanical has the greatest potential to affect the hydrograph in a local watershed. Manual vegetation controls would have minimal impacts on roadside hydrologic systems.

Unavoidable Adverse Impacts. In most cases, adverse impacts to waterways and hydrologic systems resulting from roadside vegetation management should be minor. These impacts can be minimized by maintaining rather than eliminating vegetation. To avoid adverse impacts to waterways, soil cultivation to eliminate undesirable vegetation should be discouraged. Driving heavy machinery on roadsides should also be kept to a minimum to avoid soil compaction and consequent increases in runoff.

Environmental Consequences of Treatment on Water Quality

Roadside vegetation management techniques have the potential to affect the water quality of groundwater, surface runoff, and downstream receiving waters. Potential impacts to water quality from roadside vegetation management activities are primarily related to accelerated erosion and the loss of water treatment functions. Accelerated erosion impacts from vegetation management are closely associated with soil disturbance and compaction that influence the infiltration and runoff process described in the previous section on waterways and hydrologic processes. Runoff or infiltration of herbicides and fertilizer residues could also affect water quality in groundwater and surface waters.

Roadside vegetation provides an important function in water quality control by providing both a protective cover from raindrop impact energy that accelerates erosion, and a filter strip for pollutants in highway runoff. Without the protective vegetative cover, accelerated erosion results in increased sedimentation and turbidity in receiving waters. Also, roadside vegetation provides an important water quality treatment function by filtering pollutants from the runoff. Treatments that favor dense stands of vegetation will benefit water quality.

The potential impacts on surface and groundwater quality by specific roadside vegetation management alternatives are addressed in the following sections.

Chemical Techniques. Both direct and indirect water quality impacts can result from chemical vegetation management. Direct impacts would result if: 1) herbicide application rates exceeded plant uptake rates and the excess chemicals entered runoff or groundwater, 2) herbicides were applied and then washed into drainage ways by heavy rains, or 3) herbicides were applied directly to impervious surfaces or drainage ways or indirectly to aquatic environments. Indirect impacts could result if herbicides eliminated vegetation to the degree that erosion was increased and biofiltration functions were lost. In some areas dominated by undesirable plant species, chemical techniques should be combined with cultural techniques (reseeded) that promote the establishment of desirable species and maintain vegetation cover.

Unavoidable adverse impacts to water quality from herbicide application in highway corridors should be minimal if regulations governing the use of herbicides are closely followed. Pesticides used by CDOT must be registered with the U.S. EPA and the Colorado Department of Agriculture. They should be applied according to registered label directions by a licensed pesticide applicator.

Cultural Techniques. Similar to chemical techniques, cultural techniques for managing roadside vegetation may have direct and indirect adverse impacts on water quality, particularly where chemical fertilizers are used. Both organic and inorganic fertilizer applications to promote growth of desirable vegetation should be carefully timed and controlled to avoid introducing excess nutrients to runoff waters, which in turn may stimulate algae growth and eutrophication in receiving waters. Fertilizers should not be used near aquatic environments including wetlands. Cultural techniques such as seedbed preparation that involve soil disturbance could also have water quality impacts from increased erosion.

Mulches are often used as both cultural and mechanical techniques to control roadside vegetation. Some mulches, such as wood waste and tree bark, may leach organic pollutants, particularly during the first year after placement (Horner and Mar, 1982). The use of these materials should be avoided where leachate water could impact drinking water supplies or sensitive receiving waters or in aquatic environments including wetlands.

Biological Techniques. Biological control methods do not disturb the soil, thus accelerated erosion and sedimentation impacts on water quality are minimal. Only where biological control results in extensive plant mortality would water quality be affected by reducing the function of vegetation in filtering pollutants from storm water, reseeding would be necessary in such areas.

Mechanical Techniques. Mechanical vegetation management activities that remove extensive areas of vegetation reduce the effectiveness of these biofiltration areas for pollutant removal. In addition, mowing, cutting, and trimming may temporarily reduce the ability of the vegetation to protect the soil surface from erosion and filter pollutants from storm water.

Mechanical control techniques that use heavy machinery are the most likely to compact soils resulting in significant water quality impacts from sedimentation, increased runoff and accelerated erosion. Cultivation that exposes the soil surface will increase sheet erosion and lead to gully erosion, particularly on steep slopes. Potential water quality impacts from mechanical control can be minimized by avoiding the use of heavy machinery and maintaining dense vegetation on steep slopes and in drainage swales.

Unavoidable Adverse Impacts. CDOT's standard operating practices will avoid significant adverse impacts to water quality which could occur from roadside vegetation management. Water quality can be protected or even enhanced by establishing and maintaining vegetation that functions as a biofiltration treatment system to remove pollutants from highway runoff. Effective roadside vegetation management for water quality protection should avoid improper application and spills of herbicides and fertilizers, minimize soil disturbance and compaction, and encourage a protective vegetation cover that minimizes erosion.

FLOOD PLAINS

Increased High Water

Transportation routes through the state of Colorado have historically followed the streams and rivers. Many miles of highways were located in flood plains due to topographic constraints, and land development has grown up around these transportation corridors. Encroachment onto flood plains by highways and associated developments has been an integral part of economic growth in Colorado.

Although the construction of highways has had an impact on flood plains in Colorado, vegetation management in the highway rights-of-way is not expected to have a major influence on high water levels. As previously discussed, increases in runoff from rights-of-way could occur as a result of soil compaction or increased erosion. However, the incremental increase in runoff would not normally have a measurable effect on high water levels because the rights-of-way represent only a small portion of the entire watershed contributing to floods. Vegetation management does not

involve any construction that would displace flood waters and does not have any influence on flood plain development.

Natural and Beneficial Flood Plain Values

Flood plains are recognized as providing many natural and beneficial values, including fish and wildlife habitat, scenic beauty, opportunities for scientific study and outdoor recreation, agriculture, forest resources, natural moderation of floods, water quality maintenance and groundwater recharge. The potential impacts to these values are addressed in other chapters of this manual.

Environmental Consequences of Treatment Methods

Chemical Techniques. Vegetation management through chemical techniques is not expected to have impacts on flood plains, except the minor potential impacts of increased runoff and impacts to natural and beneficial values discussed throughout this document. Increases in runoff and high water levels should be minor if soil compaction is minimized and selective herbicides are used to maintain desirable vegetation.

Cultural Techniques. Vegetation management through cultural techniques is not expected to have impacts on flood plains, except the potential impacts to natural and beneficial values discussed previously. Mulch or other soil amendment materials should not be stockpiled within floodplain boundaries to avoid displacement of flood waters. Once applied, these materials will have a minor benefit in reducing runoff from the rights-of-way.

Biological Techniques. Vegetation management through biological techniques would not have any impacts on flood plains, except the potential impacts to natural and beneficial values previously discussed.

Mechanical Techniques. Mechanical vegetation management has the potential for impacts to flood plains through minor increases in runoff resulting from soil compaction or reduced evapotranspiration. Increases in runoff should be minor if soil compaction is minimized and plants are removed selectively.

Unavoidable Adverse Impacts. No unavoidable adverse impacts to flood plains are anticipated from roadside vegetation management.

WETLANDS

Description of Wetlands

Wetlands provide a transition between land and water environments. They are lands where groundwater is usually at or near the surface, or where the land is covered by shallow water for all or part of the year. Wetlands are further defined as lands where saturation with water is the dominant factor determining the nature of soil development and the types of plants and animal communities living in the soil or on its surface

Wetland Functions

Wetlands perform many ecologically important functions. These functions vary from wetland to wetland, but include providing water quality protection, flood control, shoreline stabilization, contributions to groundwater and stream flows, and wildlife and fisheries habitat. Wetlands are also valued as natural areas providing aesthetic, recreational, and educational opportunities.

Water Quality Protection. Wetlands improve water quality by three pollutant removal processes: sediment trapping, nutrient removal, and chemical detoxification. Suspended particulate matter and sediments are deposited in wetlands when runoff flowing through wetlands is slowed by resistance of plants. The roots of the vegetation can then bind the accumulated sediments. Where wetlands precede deeper waters, suspended particulates reaching lakes or streams which could destroy fish spawning habitats by clogging gravel beds are trapped. Additionally, because many pollutants sorb to soil particles, the filtering action of the wetland further improves water quality.

Pollutants trapped along with settled soil particles may be buried in the sediments, while others may be converted to less harmful chemical forms by biochemical processes. Still, other pollutants may be taken up by plants and either metabolized and recycled within the wetland or transported from it.

Functionally wetlands also serve as a trap for excess nutrients. An overabundance of nitrogen and phosphorus in surface waters can promote excessive plant and algal growth, resulting in a degradation of water quality. These nutrients can accumulate in wetland sediments where they may be converted by microorganisms into forms which are unusable or less usable to plants and algae. Other nutrients may be taken up by wetland plants and converted into plant material.

Flood Control. Wetlands have the capacity to store floodwaters, particularly in frequently flooded forested areas along rivers and those with organic soils. During high runoff, these wetland soils temporarily store some of the flood waters much as a sponge soaks up water. After the flooding, the water is released slowly from the wetland soils, thus reducing the severity of downstream flooding and erosion (WSDOE, 1988). These wetlands, also provide flood control along roads. This flood control not only protects the roadway investment but it provides a safer driving environment.

Shoreline Stabilization. Vegetated wetlands along shorelines can protect against shoreline erosion caused by waves along shores of lakes or river currents during floods. Wetland vegetation can absorb much of the energy of the surface waters and binds soil and sediments in its dense root systems. These wetlands are important stabilizers for road beds that are built adjacent to or through wetlands.

Groundwater Recharge and Streamflow Maintenance. Wetlands can temporarily store water that moves through the underlying soil and enters the local or regional groundwater system. Such movement of surface water into the groundwater system is called groundwater recharge, and occurs when the soil permeability and structure permit.

Water stored in wetlands during wet periods may also be released slowly to adjacent streams during drier periods. This water is important in maintaining stream flows necessary for the

survival of animals and other wildlife, fish, plants, and other organisms that live in or near the stream.

Wildlife and Fisheries Habitat. Wetlands provide essential habitat and food for numerous wildlife species. Many species of waterfowl and freshwater and saltwater fish require wetlands for breeding, nesting, or as nursery grounds.

Education and Recreation. Because they contain a variety of flora and fauna not found in other environments, wetlands provide unique educational and scientific research opportunities. The diversity of wetland plant life (over 5,000 species nationwide) creates habitats for nearly every form of animal life. The preservation of this genetic diversity is critically important in light of the rapid extinction of species taking place worldwide.

Also, the unknown potential of wetland plants and animals to provide new foods, chemicals, or drugs contributes to the value of wetlands in their natural state. In some cases, control of invasive weeds, such as eastern marsh grass or purple loose strife may be of benefit to the preservation of these systems.

An important quality of wetlands is their value as scenic and recreational areas. Recreational use of wetlands is increasing nationwide and includes hiking, boating, fishing, hunting, and wildlife observation (WSDOE, 1985).

Environmental Consequences of Treatment Methods

The potential impacts of roadside vegetation control methods on wetland habitats and resources are directly related to any impacts upon water quality. Potential adverse effects include reduced survival or reproduction of aquatic organisms resulting from habitat degradation or toxic effects. These impacts have been evaluated in the aquatic risk assessments reported in other sections of this document.

The quality of wetland habitats depends on hydrology, water temperature, total dissolved oxygen, food supply, protective cover, sediment and nutrient loads, availability of spawning and nursery areas, and the presence of toxic materials. Wetland habitat degradation resulting from increased sediment and nutrient loading is the most likely adverse effect of vegetation control along CDOT rights-of-way. Impact could be caused by any of the identified treatment methods (grading, hand pulling, trimming, or chemical control). Effects could include turbidity-induced gill abrasion, covering of spawning habitat, and reduced oxygen levels from the eutrophic effects of increased nutrient loads.

Conversely, noxious weeds which invade and consume wetland areas may need to be controlled or eliminated by CDOT maintenance activities. All work must be cleared with the Regional Environmental Manager. Wetlands are protected by State federal and local laws.

Chemical Techniques. Chemical methods of vegetation management along CDOT rights-of-way can potentially have both direct and indirect effects upon wetland habitats and resources. The use of chemical methods can have effects on water quality because of accidental direct application, spray drift, and the transport of herbicides to surface waters due to runoff.

A number of indirect effects to wetland habitats are possible as a result of herbicide application to CDOT rights-of-way. Non-selective chemical methods can contribute to soil erosion by removing all vegetation cover. Soil erosion can result in increased sedimentation in adjacent wetlands, injuring or destroying spawning and nursery areas. Erosion can also reduce shoreline stability along streams resulting in loss of protective cover for organisms utilizing such habitats.

Direct application of herbicides to wetland areas could potentially impact wetland vegetation; thereby degrading many of the functions of a wetland, including water quality protection, flood control, shoreline stabilization, contributions to groundwater and stream flows, and wildlife and fisheries habitat. It is necessary to contact the Regional Environmental Manager before spot spraying aquatic-approved herbicides.

However, there are currently a few aquatic plant species that are considered to be pests and are controlled only through the use of herbicides. These include purple loose strife that invades and eliminates wetlands.

Cultural Techniques. Cultural techniques, specifically the use of organic or inorganic mulches, generally have a low potential for adversely affecting wetland habitats. However, excess nitrates and urea compounds can be introduced through the use of fertilizers. These compounds can alter the pH and nutrient balance of aquatic environments.

Biological Techniques. Biological techniques, such as the introduction of pest organisms or the introduction of insects and plant pathogens, are not likely to adversely impact water quality. Both of these techniques are species specific and are therefore very selective. Erosion is not a likely consequence of biological techniques and non-target effects are minimal.

Mechanical Techniques. Mechanical methods, such as mowing, generally have a low potential to impact wetland habitats through soil erosion because they result in substantial retention of soil cover. However, clippings may lead to a decline in dissolved oxygen due to vegetation decomposition. Grading and disking create a high potential for soil erosion by exposing soil which can then be carried to aquatic habitats during storm events. The resulting sedimentation can thus degrade aquatic habitats.

Unavoidable Adverse Impacts. Any of the techniques employed for the management of roadside vegetation are likely to adversely impact the environment to some degree. As discussed above, the most likely impact is that from soil erosion due to elimination of ground cover. In the case of herbicide application, some of the herbicide will possibly be deposited directly in wetland habitats as a result of spray drift or surface runoff. The degree of impact is dependent upon the concentration to which nontarget organisms are exposed and the duration of that exposure.

VEGETATION

In the following discussions, the concepts of vegetation zone and roadside management zone must be maintained as separate entities. A vegetation zone is an environmental subsection of a province supporting relatively homogeneous plant communities dominated by a specific group of potential climax plant species. These zones cover thousands of acres, and consequently encompass widely varying topographic and physiographic conditions.

The plant community descriptions for each of the vegetation zones refer to relatively undisturbed, long-term stable, mature, old-growth, or climax conditions. The amount of time required for the plant composition on disturbed sites to stabilize depends on the site; the type, degree and season of disturbance; the seed source or invading plants; and climatic conditions. Early forest successional stages generally take centuries to develop into what is truly considered a climax stand of vegetation.

Highway cut and fill slope construction (Roadside Management Zone 1 and Zone 2) generally results in soil conditions unlike any under the adjacent natural vegetation. Therefore, it cannot be assumed that roadside vegetation will have the same species composition or productivity as occurs outside the heavily impacted construction zones. Roadside Management Zone 3 is much less disturbed during construction and subsequent roadside management, and adjacent, naturally occurring plant communities will probably establish easily. Species composition of disturbed vegetation can be so variable that potential invading species may only be partially assessed through knowledge of the long- term stable community composition and the environmental conditions they require. Species composition on all three management zones will be a function of soil conditions, contractor hydroseeding/planting, seed sources available in adjacent habitats, and seed transport by vehicular traffic from all other areas of the State, as well as other regions of the country.

Cultural. Cultural techniques for roadside vegetation maintenance utilize highly competitive communities of desirable species to fully occupy the site. Once established, these communities of preferably native species will fill all available growing sites and maximize the use of soil moisture and nutrients. Weeds and noxious plant populations are kept at low levels, or often from invading at all, by not having suitable sites for establishment and reduced availability of moisture and nutrients required to sustain the vigorous growth needed to outcompete the existing vegetation.

Initial establishment of desirable communities on highly disturbed roadside zones can be costly in both time and materials. The use of mulches, landscaping cloth, fertilizer, hydroseeding, and direct plantings of seedlings must all be coordinated to complement each other. Since weed species will aggressively invade during initial establishment, their exclusion from the original community may require the additional use of chemical or mechanical treatments until the desired vegetation can dominate.

Routine maintenance on sites following successful establishment of a desirable native plant community is very low. Spot treatments, mechanical or chemical, may be needed to arrest small invasions of undesirable plants. Proper selection of original community species will provide the low-growth form and soil cover properties which do not require mowing, trimming, or other growth inhibiting treatments. Although they are more difficult to implement, the successful application of cultural techniques is the most efficient and cost-effective treatment for the long-term management of roadside vegetation.

Biological. Biological control of undesirable roadside species, both plants and animals, is a relatively inexpensive technique to apply, but it generally takes a number of years to effectively produce results. Also, biological controls are unable to eradicate host species, creating a cyclical pattern of first decreasing host numbers, then decreasing control populations, followed by

increasing host species numbers, then by increasing control species. These population swings create a potential for future outbreaks of the host weed species if anything happens to weaken the control before their populations can regain effective numbers.

Mechanical. Mechanical and manual control techniques using tractor-mounted sickle bars, flails or rotary mowers and hand-operated chainsaws, brushsaws or mowers are often used to control small trees, shrubs, and herbaceous vegetation. Repeated cutting of vegetation on medians and side slopes can have widely varying results, depending on the species being controlled, the methods applied, and the timing.

Removal of streamside vegetation must be approved by the DOW, and requires notification of the Regional Environmental Manager.

When shrubs and trees are controlled by mechanical methods they often resprout from roots and root-crowns creating higher plant stem densities than before control. Many shrubs and resprouting tree species respond most vigorously after above ground material has been removed during the dormant season. These species often produce more and bigger stems, limbs, and suckers than if they were not pruned at all. Mechanical vegetation control measures must be applied in a manner that most adversely affects the target species. Proper timing and application of treatment is critical, otherwise removal of regrowth may be required two or more times per year.

Environmental Consequences of Treatments Methods

The goal of roadside vegetation management is to maintain plant communities having the desired growth characteristics for roadside safety and aesthetics, that require low maintenance needs, and that provide storm runoff biofiltration capacity while not greatly impeding flows. Vegetation management techniques available to create the desired conditions can be in the form of chemical, cultural, biological, or mechanical treatments. Each of these treatments has widely varying costs, both financial and environmental, that often change from district to district and even between vegetation zones within one district.

Vegetational responses to roadside management programs can only be assessed in this document in a very generalized manner. Evaluation of vegetation responses to disturbance relationships varies on each individual project. Every combination of trees, shrubs, forbs, and grasses can respond to treatment in a different manner. The variation in response is often increased when native and exotic species are intentionally planted along rights-of-way. The plant community response, as opposed to individual species responses, often depends upon climate; species composition, dominance, and phenology; treatment type and degree; and site properties and conditions.

In areas of highly intensive agricultural activity, sometimes the only remaining examples of individual species or high quality native plant communities are located in Roadside Zone 3, between the actively managed road system and the annually disturbed agricultural fields. These areas should be avoided if possible. In areas that serve as habitat the DOW must be contacted as per existing Memoranda of Understanding.

No Vegetation Management Activities. If no vegetation management activities were used to control roadside vegetation, nature would take its course. The natural biological requirements of plants provides them with highly competitive niches. Under this alternative, any native or exotic plant species which can establish in direct competition with other plants would grow unimpeded by management activities.

The changes within a plant community brought about by the ability of one plant to become dominant over others on a site is called succession. Some plants are highly competitive in full sun, low soil moisture conditions while other plants can establish and crowd out others in deep shade or saturated soil conditions. On landscapes without vegetation management activities, natural successional trends could progress through any of the following plant communities.

1. Rock outcrop with lichens and mosses;

2. Shallow soils with little organic matter, annual grasses and forbs;

3. Shallow to moderate soils, some organic matter, perennial grasses and forbs;

4. Moderate to deep soils, shrubs, perennial grasses and forbs;

5. Moderate to deep soils, pioneer trees (conifer or deciduous), shrubs;

6. Moderate to deep soils, mid-successional conifer trees, little understory vegetation; or

7. Moderate to deep soils, climax trees, mostly coniferous species.

Any of these plant communities could establish as the long-term stable dominant vegetation for a site depending on soils depth, fertility, moisture-holding capacity, local precipitation amounts and regimes, past disturbance severity, and adjoining vegetation composition.

Over time, vegetation develops along normal successional lines. The highway ROW has areas where soil has been disturbed during construction (Zones 1 and 2) and areas where soil often has not been disturbed (Zone 3). On sites where some topsoil remains or has been replaced following construction, desirable native species can be established rapidly. If not controlled, the highly disturbed areas of RIGHTS-OF-WAY (cut and fill slopes of bare soils) will revert to early successional plant communities composed of weedy annual and perennial grass and forb species. On sites where all upper soil horizons have been removed, a pioneer species community will dominate the disturbed site for long periods of time. Areas where the native soils remain intact will proceed along the successional line quicker and reach a given areas climax vegetation community faster than highly disturbed areas.

A no action approach to roadside vegetation management is undesirable because of the need to meet requirements of local weed control districts, highway safety, and design requirements. Under the no action option, native and exotic weedy vegetation generally establish and dominate areas of ROW that are without vegetation. Weed dominance on RIGHTS-OF-WAY may result in creating an attractant for undesirable insect populations and diseases. This then creates another

problem if it occurs adjacent to large scale agricultural operations. Although most agricultural pests are controlled directly on the crop, effective and economical control of noxious weeds, insects, and diseases requires that additional repositories, such as, ditches and RIGHTS-OF-WAY also be free of host species.

Chemical Techniques. The application of herbicides is used to remove or retard vegetation growth on road shoulders, ditches, and rights-of-way. It is best if herbicides are used to improve the potential for success of desirable vegetation, but often, chemical controls are utilized as a rapid, inexpensive means to remove all vegetation from Roadside Management Zone 1 and portions of Zone 2. Herbicide usage requires a large investment in planning of proper chemical selection, application rate, phenology of target and non-target species, site-specific environmental constraints, and planning for the safety of applicators and all potential off-site recipients of residues.

Herbicides used by CDOT range from non-selective pre- and post-emergence soil treatments to highly selective foliar-applied chemicals that target relatively narrow groups of broad-leaved forbs, shrubs, and trees. Where desirable vegetation is established on slopes and medians, spot treatments of individual plants or small, localized populations with selective herbicides are very effective for maintaining and enhancing the growth of grasses and coniferous trees and shrubs. If desirable vegetation has not been previously established, applications of non-selective, non-residual herbicides generally results in rapid reinvasion by weedy species, necessitating additional treatments in the future.

The impacts of chemical treatments vary depending on how closely the target and non-target species are related, the selectivity of the herbicide, and the application method, timing, and rate. Populations of annual plants are generally more sensitive to herbicides than are perennials, especially if treated before producing seed. Annual and perennial weed species that have been established at a site for a few years often have large seed reserves in the upper soil horizons and will require repeated control measures. Retreatment may be required until the majority of weed seeds have germinated and highly competitive, desirable vegetation has become established on the site.

Rainfall following or windy conditions causing drift during herbicide applications along road edge, ditch, and backslopes may result in residue contamination of storm water runoff and non-target areas. Poorly planned or executed herbicide applications often remove or damage both desirable and undesirable vegetation. It is important that CDOT continue it's efforts to prevent the misapplication of herbicides and keep any negative impacts of herbicide application to a minimum. Removal of all vegetation with non-selective herbicides creates sites for accelerated soil erosion and invasion by undesirable plant species. This practice should only be conducted when areas are to be promptly reseeded and properly mulched. Applications of broad-leaf selective herbicides may lead to grass dominated monocultures along roads. Monocultures of any life-form are subject to invasion by insects or diseases which may subsequently denude the site entirely.

Cultural Techniques. Cultural techniques can be used to establish highly competitive, stable, native plant communities in order to meet CDOT roadside vegetation goals. This approach entails planting and fertilization of desirable vegetation, with minimal application of chemical and mechanical treatments to reduce undesired plant competition. Establishment of native species

generally creates plant communities having resistance to native insect and disease problems, while also maintaining vegetative cover that is well adapted to local climatic conditions.

Biological Control. Biological treatment with species-specific plant-eating insects or pathogens should have no adverse impacts on non-target plants. All insects and pathogenic organisms used in biological control are evaluated for host-specificity by the United States Department of Agriculture, Animal and Plant Health Inspection Service, prior to authorizing release of the agent into the environment. There is great complexity involved in application of biological controls. Environmental tolerances of both the plants to be controlled and the biological control vectors often do not overlap exactly. The St. John's-wort beetle, a host-specific, plant-eating insect, is easily transplanted from site to site, but does not over-winter well in Colorado due to elevation. Flea beatles and cinnabar moths, biological controls for tansy ragwort, have proven to be very effective controls at elevations over 5,000 feet once they have been acclimatized to the elevation.

Although biological control techniques often take more time to establish insect or pathogen populations which can effectively control the target plant, the initial cost is the least expensive to implement of all control techniques. The establishment and management of stable, desirable plant communities through biological control of a single undesirable plant species should result in reduced need for more disruptive types of vegetation control in the future and over the long-term will provide greatly reduced maintenance costs.

Mechanical Control. Tractor-mounted sickle bars and flail or rotary mowers are used to control small trees, shrubs, and herbaceous vegetation. In urban areas, fast growing herbaceous species require periodic mowing throughout the growing season. Repeated mowing of grass and forb species on medians and road side slopes often weakens the plants and mechanically affects soil surfaces. Operation of even light-weight tractor-mounted mowers on wet, fine-textured soils, can remove vegetative cover allowing for invasion of undesirable species or will compact subsurface soil layers leading to surface erosion and slumping of soils.

Grass-forb communities, a major component of the roadside vegetation in many areas, remain in best health when allowed to complete their natural life-cycle of flowering and summer/fall die-back. Frequent mowing to create the appearance of a lawn reduces grass species vigor and removes flowers before seeds mature fully. Mid- to late-summer mowing of dried vegetative material can aide the spread of seeds and incorporation of organic matter into the generally poor roadside soils. Dry season operation and use of low ground-pressure maintenance equipment can moderate possible soil disturbance from mechanical vegetation control.

Selection of the best mechanical method for treating vegetation in a particular roadside location depends on:

1. Characteristics of the plant species to be removed (e.g., stem size and density, brittleness, resprouting ability, and phenologic stage of growth);

2. Characteristics of plant species to be enhanced or established (e.g., need for seedbed preparation and natural versus planted revegetation);

3. Roughness or steepness of topography and terrain;

4. Soils characteristics (e.g., type, depth, amount and size of rocks, erosiveness, moisture content, and susceptibility to compaction); and

5. Climatic conditions.

Manual methods for managing vegetation are also considered as mechanical techniques. Here hand tools and hand-operated power tools are used to cut, clear, or prune vegetation generally above or at ground level to enhance site conditions for desired plants. Due to the scale of Department of Transportation projects, this control method is relegated to use where chemicals are not feasible and mechanized equipment can not operate safely.

Site disturbance is minimal with manual treatment techniques, however, the ability to affect plant community composition is also highly limited. Pulling or digging out plant root systems to prevent sprouting and regrowth is extremely difficult to impossible in the often highly compacted, high gravel content soils at road edges (Zone 1) and on adjacent slopes (Zone 2).

When shrubs and trees are controlled by manual methods they often resprout from roots and root-crowns creating higher plant stem densities than before control. Proper timing of manual control treatment is critical, otherwise removal of regrowth may be required two or more times per year. Other than roadside areas infested with small populations of noxious weeds, forbs, and grasses are generally too numerous to be controlled efficiently by this technique.

Most grass and forb species maintain best health and vigor when allowed to complete their natural life-cycle of vegetative growth, flowering, seed maturing, and summer/fall die-back. Many shrubs and resprouting tree species respond most vigorously after pruning has occurred during the dormant season. Many species often produce more and bigger stems, limbs, and suckers than if they were not pruned at all. Manual vegetation control measures should be applied to most adversely affect the target species.

Manual control appears to be the most costly vegetation control technique available due to the labor intensive work, the potential need to visit a site at different times to treat different-species and the often marginal results in controlling regrowth. The application of manual control is desirable, though, since it can be highly selective of species or individual plants being targeted. Nontarget species would be beneficially affected through minimal exposure to disturbance and reduced competition from target species for nutrients, water, and space. Effectiveness of this control technique will not vary greatly with its application in different regions throughout Colorado.

WILDLIFE AND WILDLIFE HABITAT

The same range of environmental parameters that contributes to such a wide variety of plant species also provides a wide variety of wildlife habitats that can support a number of different kinds of wildlife communities throughout the State.

Environmental Consequences of Treatments

Roads affect wildlife populations through their effects on habitats and animal movements. Depending on the type of road and the characteristics of the surrounding habitat and wildlife community, roads can act either as corridors or barriers to animal movements, enhancing or isolating populations. In forested landscapes, for example, species such as coyotes that favor open habitats utilize roadways as travel and hunting routes. Other animals, such as elk, typically (though not always) avoid well-traveled roads. Smaller vertebrates may choose not to cross roads at all.

Roadside vegetation management can influence wildlife populations through its effect on habitat. Effects may be either beneficial or harmful depending on the location, site characteristics, species affected, and the timing, intensity, and frequency of treatment. In most cases the effect depends on the habitat changes caused by the treatment rather than the particular method utilized. The extent that vegetation management supports habitat use and normal movements of desirable native species of wildlife can be a beneficial management tool. Vegetation management becomes harmful when it causes a significant increase in road kills, reduces the structural and compositional diversity of native vegetation, or promotes the dispersal of opportunistic, invasive organisms (either native or non-native). It is imperative that wildlife and habitat responses to vegetation management be evaluated on a site-specific, individual treatment basis.

Eliminating roadside vegetation treatments could result in improved wildlife habitat on some sites. Lack of periodic disturbance to soils and vegetation would allow native plant communities to remain or become established, favoring animals associated with these habitats.

The potential impacts of roadside vegetation control methods on aquatic habitats and resources are directly related to any impacts upon water quality.

Chemical Techniques. Impacts of chemical vegetation control are direct, toxicological effects, and indirect effects from habitat alterations.

Habitat changes resulting from herbicide applications are beneficial to some animals and harmful to others. Spraying of shrubs has been found to reduce breeding bird populations in sagebrush communities, as well as mule deer use of forested plantations (USDI, 1991; DNR, 1983). These effects were attributed to reduced nesting cover for shrub-nesting birds and a decrease in preferred browse species and fawning cover for deer. In another study, herbicide treatment of grasses and forbs led to a decline of small mammals adapted to grassy habitats and an increase in species preferring shrub communities (DNR, 1983). Chemical treatment of noxious weeds is beneficial to most, but not all, wildlife species, since some plants are highly utilized as food. Seeds of thistles and other annual weeds, for example, are eaten by many species of finches.

As with other treatments, the response of wildlife to chemical control depends on the chemical used, how it is applied, its effect on habitat, and the availability of cover and forage in treated and adjacent untreated areas. Broadcast use of non-selective herbicides is most damaging to wildlife habitat, because it removes both desirable and undesirable vegetation. For this reason, such treatments should be minimized in Zones 2 and 3 of the highway right-of-way in favor of direct applications or use of selective herbicides, which treat only target plants. Nonselective chemical

suppression of vegetation in Zone 1 is used to maintain structural integrity of the road and driver safety, and should not harm wildlife habitat.

Chemical methods of vegetation management along CDOT rights-of-way can potentially have both direct and indirect effects upon aquatic habitats and resources. The use of chemical methods can have substantial effects on water quality because of accidental direct application, spray drift, and the transport of herbicides to surface waters due to runoff.

Herbicide residues can be mobilized by surface transport or overland flow, entering surface waters in solution or adsorbed on particulate matter.

Herbicides entering aquatic environments may directly impact prey species, reducing their numbers, and thus indirectly affecting predator species.

Cultural Techniques. Cultural control of roadside vegetation, through planting of desirable competitive native species, has the potential to improve wildlife habitat along roadsides. Animals would benefit, for example, by planting of species utilized as food. Where plantings result in the establishment of native plant communities and the reduction of noxious weeds, wildlife will also benefit. Improper use of roadside plantings could, in some circumstances, harm wildlife by reducing driver visibility and increasing the risk of collisions with animals. In roadside areas where deer and elk populations are likely to be a problem, it may be advantageous to plant low-growing species that are relatively unpalatable to these animals.

Cultural techniques, specifically the use of organic or inorganic mulches, generally have a low potential for adversely affecting water quality.

Biological Techniques. Biological control is a long-term process with significant potential for roadside habitat improvement. Some of the undesirable target plants cause serious economic losses in many parts of the State by poisoning livestock or by displacing desirable forage for both wildlife and livestock. To the extent that biological control allows more palatable native vegetation to become established along roadsides, wildlife habitats will improve. Whether this will result in greater wildlife use of roadside habitats depends on plant community characteristics, adjacent habitat types, and affected wildlife species.

Biological techniques, such as plant competition or the introduction of insects and plant pathogens, have the potential to promote soil erosion by eliminating ground cover. The resulting erosion can thus degrade water quality and aquatic habitats.

Mechanical Techniques. Hawks, other predators, and scavengers are frequently attracted to highway corridors, where they hunt for small mammals along median strips or feed on animals killed by motor vehicles. In situations where mechanical control is used to reduce tree cover along highways, the subsequent growth of shrubs and herbs can improve habitat for small mammals, birds, and arthropods. Greater prey abundance may improve conditions for predators and scavengers, resulting in more roadside use and increased exposure to collisions with vehicles. Although the extent of highway mortality of predators and scavengers is unknown in Colorado, it could be relatively important, since these animals have few natural enemies and mortality may otherwise be relatively low.

Mowing of roadside vegetation reduces nesting and hiding cover and food availability for small birds and mammals. Mowing during the breeding season can damage habitat, reduce productivity of ground-nesting birds, and destroy nestlings. On the other hand, mowing may stimulate the production of palatable grasses and forbs, attracting deer, elk, and other large mammals to roadsides. Use of mechanical equipment can result in soil compaction and accelerated erosion, damaging the habitat of burrowing animals. The widely varied effects of mechanical treatments on wildlife dictate the need for site-specific analysis.

Manual control techniques are generally reserved for sites where other methods of vegetation control are impractical, and for selective removal of noxious weeds. Wildlife habitat is affected by removal or alteration of specific plants that may be utilized for food and cover. Because manual control methods are labor intensive, treatments are usually very localized. Resulting wildlife impacts are therefore usually minor.

Mechanical methods, such as mowing, generally have a low potential to impact aquatic habitats through soil erosion because they result in substantial retention of soil cover. However, grading and disking create a high potential for soil erosion by exposing soil which can then be carried to aquatic habitats during storm events.

Unavoidable Adverse Impacts. Chemical treatment of roadside vegetation in Zones 2 and 3 adversely affects the habitats of some wildlife species. The fact that vegetation is being removed makes this impact unavoidable. Using selective herbicides or spot applications of non-selective herbicides can reduce adverse impacts on wildlife habitat. Use of pre-emergent herbicides also eliminates impacts on established vegetation, but can affect annual plant growth used as food or cover by some animals.

Mowing and other mechanical treatments in roadside Zones 2 and 3 can result in soil compaction, disturbance, and increased erosion. These impacts can be mitigated, but not totally eliminated, by operating during the dry season.

Mowing can also adversely affect wildlife habitat value. The severity of impact will depend upon a number of factors, including types of vegetation being treated (grasses vs. small trees and shrubs), existing wildlife use, season of operation, and the depth at which the vegetation is mowed. Site-specific review of environmental factors when considering mechanical treatments could reduce adverse effects on animals and their habitats.

Cultural and biological vegetation treatments on roadsides produce no significant unavoidable adverse impacts on wildlife habitat.

Any of the techniques employed for the management of roadside vegetation are likely to adversely impact the environment to some degree. As discussed above, the most likely impact is that from soil erosion due to elimination of ground cover. In the case of herbicide application, some of the herbicide will undoubtedly be deposited directly in aquatic habitats as a result of spray drift or surface runoff. The degree of impact is dependent upon the concentration that nontarget organisms are exposed to and the duration of that exposure.

AIR QUALITY

This section discusses existing conditions that influence background air quality in the State of Colorado. The discussion provides information on natural conditions (topography, climate), sources of anthropogenic emissions (vehicle emissions, industrial emissions, home heating), and other factors to form a context within which to evaluate potential impacts from the four alternative roadside vegetation treatment methods (chemical, cultural, biological, mechanical) addressed in this manual.

Odor

Many of the emission sources noted above may produce adverse odors. Various sources of combustion (vehicle and motorized equipment exhaust emissions, industrial fuel use, home heating with wood) emit objectionable sulfur oxides (SOx), nitrogen oxides (NOx), and hydrocarbons, as well as the colorless and odorless carbon monoxide, carbon dioxide and water vapor. These emissions may have adverse impacts on the existing air quality along transportation corridors prior to any additional impacts attributable to vegetation management practices.

Existing sources of odors associated with highway transportation corridors are generally dominated by vehicle exhaust emissions. Other minor sources of highway-related odors include tar and asphalt from road construction and maintenance, volatilization of existing materials during hot weather, and occasional road kills.

Sources of odor from roadside vegetation management include the vegetation itself and odors from chemical treatment methods (herbicides and fertilizers). Vegetation odors may have subtle variations, depending upon species composition, and are generally considered pleasant. Natural decomposition processes associated with decaying vegetation and marshy areas may have objectionable odors.

It is important to note that the presence of an odor does not necessarily indicate that a chemical or fertilizer application has been improperly administered, or that there is a risk to human health or the environment. In many cases (depending on the properties and toxicity of the specific chemical) the odor threshold may be at a concentration substantially lower than the regulatory levels of concern for potential health effects.

Chemical Content

Various sources of emissions from sources other than vegetation management practices contribute to chemical contamination of the air. Combustion sources in general, as well as vehicles in particular, contribute varying amounts of SOx, NOx, hydrocarbons, carbon monoxide, and carbon dioxide. Incompletely burned gasoline from poorly maintained vehicles may contribute emissions of a variety of volatile organic compounds (VOC's), including benzene, a known human carcinogen.

Particulate Content

Many of the existing sources of emissions result in increased levels of airborne particulates. Motor vehicle and other motorized equipment exhaust, particularly diesel-fueled engines, produce high rates of particulate emissions, including particles in the size range of concern for health effects.

Environmental Consequences of Treatment Methods

Chemical Techniques. Potential environmental consequences of chemical treatment methods on air quality include:

- Occupational exposure of chemical applicators from inhalation of spray or direct contact with chemicals;
- Exposure of other human populations (e.g., downwind residents, passing motorists, children playing in treated areas);
- Exposure of non-target plant species, wildlife, and other organisms present in the application area or visiting the area during periods when residuals of applied chemicals are present; and
- Odor impacts associated with the use of specific chemical formulations.

It is recommended that the following be used as applicable:

- Implementation of appropriate occupational health and safety and controls for herbicide applicators;
- Restriction of herbicide application to environmental conditions that reduce the probability of drift;
- Post appropriate warning signs to inform the public of any potential hazards associated with treated areas;
- Appropriate procedures should be followed for notification of chemical sensitive people;
- Select and apply herbicides in a manner consistent with Federally-approved label warnings to minimize the potential for exposures to non-target species; and
- Select and apply herbicides that have the lowest degree of adverse odor impacts associated with an acceptable degree of herbicidal effectiveness.

Cultural Techniques. Potential consequences associated with cultural treatment techniques include:

- Preparation of seedbed or planting areas could result in particulate emissions. These impacts would be expected to be short-term and localized. Conversely, after implementation of cultural techniques to promote healthy desirable plant communities, the potential for windborne erosion of soils would be expected to decrease with the development of root systems and ground cover; and

- Potential odor impacts from use of organic or chemical fertilizers. These impacts would be expected to be short-term and localized.

Positive impacts of enhanced vegetation include:

- The reduction of acreage requiring annual maintenance could result in reduction of vehicle emissions associated with alternative vegetation management activities.

CDOT recommends mitigation methods that could be used to reduce the impacts of cultural techniques on air quality include:

- Reduction of activities, such as the disturbance of soils, to periods when weather conditions are likely to result in minimal generation of particulate emissions (e.g., when soils are damp);

- Use of dust suppression techniques where appropriate (e.g., water spray to reduce airborne dust emissions from soils disturbed by machinery); and

- Seeding or planting and mulching as soon as practical after soil preparation is completed.

Biological Techniques. Biological control agents approved for use in Colorado are considered to have no adverse impacts on air quality when properly applied and managed.

Mechanical Techniques. Potential environmental consequences of mechanical treatment techniques on air quality include:

- Odor impacts from exhaust emissions;

- Other adverse air quality impacts associated with exhaust emissions from powered machinery (VOC's, CO, NOx, SOx, particulates, etc.); and

- Potential generation of airborne particulates during activities such as grading, mowing, and cultivation.

Potential mitigation methods that could be used to reduce the impacts of mechanical techniques on air quality include:

- Where feasible, use electrically-powered equipment as a replacement for gasoline or diesel equipment to reduce objectionable odors and potential adverse health effects from exhaust emissions; and

- Restrict activities such as the disturbance of soils during mowing and cultivation to periods when weather conditions are likely to result in minimal generation of particulate emissions (e.g., when soils are damp).

Unavoidable Adverse Impacts. Potentially unavoidable adverse impacts of roadside vegetation management on air quality may include the following:

- Odor during application of herbicides or fertilizers;

- Dust emissions from activities that disturb soils which must be conducted during dry weather (e.g., cultural or mechanical techniques);

- Exhaust emissions from activities that require the use of motor vehicles or gasoline/diesel powered equipment; and

- Risk of exposure of people, wildlife, and other organisms to airborne chemicals in areas where it would be impractical to remove potentially exposed organisms or prevent their entry during or shortly after chemical applications.

VISUAL QUALITY

One of the primary goals which vegetation management of highways strives to achieve is a visual integration of the highway with the adjacent land uses and not to create a separate entity within the overall landscape. Much of the definitions and methods for assessing visual quality are taken from "Esthetics and Visual Resource Management for Highways" as developed for the U.S. Department of Transportation and the Federal Highway Administration by Jones and Jones and the Washington State Department of Transportation.

The visual quality of a highway is measured in terms of the extent of visual elements offered along the highway. Visual elements include landforms, vegetation, water, color and adjacent scenery. Visual elements are measured by the sum of four basic criteria; vividness, intactness, unity, and compatibility.

Vividness: "The memorability of the visual impression received from contrasting landscape elements as they combine to form a striking and distinctive visual pattern."

Intactness: "The integrity of visual order in the natural and man-built landscape, and the extent to which the landscape is free from visual encroachment."

Unity: "The degree to which the visual resources of the landscape join together to form a coherent, harmonious visual pattern. Unity refers to the compositional harmony or inter-compatibility between landscape elements."

Compatibility: "The degree to which development with specific visual characteristics is visually unified with its setting."

"Esthetics and Visual Resource Management for Highways" is used as a guide for assessing the visual quality and impacts of proposed highways. The document addresses techniques to make evaluations and judgements on a site specific basis. State-wide vegetation management, however, is not site specific and many of the techniques described in the document do not apply. The key elements, vividness, intactness, unity, and compatibility can be utilized in conceptual terms. In assessing the visual quality and impacts of vegetation management techniques, many generalizations must be made which may overlook unique visual situations. Those unique situations should be examined on a site specific, case by case basis.

Unique Situations

Scenic Highways, Parks, and Points of Interest. Designated scenic highways, national parks, recreation areas, and other scenic points of interest are highly sensitive to visual changes. Most scenic areas are located in natural environments and are focused around the natural features. Roadside vegetation management is usually perceived as an intrusion into the natural landscape.

Speed of Travel. The impression of the visual quality can change as speed of travel changes. At slower speeds, details are more noticeable. For example, at high speeds a viewer may notice a mass of shrubs and associate them with a large planting bed. Where at slower speeds they may see that those plants are really weeds and consider them undesirable.

Traffic Volume. High volumes of traffic and urban congestion can greatly detract attention from visual resources. In high volume areas, motorists must pay close attention to the road and to other vehicles. Roadside vegetation becomes excess information to someone attempting to navigate todays urban traffic. On the other hand, mass transit, car pools, and van pools expose large amounts of viewers to the highway environment each day. The users of the transit system spend more time viewing the roadside vegetation and are more aware of changes especially at slow, rush hour speeds.

Views. Vegetation management can significantly impact views. Desirable views can be created by clearing or trimming taller vegetation. Vegetation can be used to frame, enhance, and draw attention to specific views. In many areas, the roadside vegetation is the primary visual element along the highway where views are limited by tall vegetation and high embankments on both sides of the highway. The landscape treatment should provide visual relief between the roadway and adjacent land uses. Roadside vegetation can also serve as a buffer strip to significantly screen the road from adjacent properties and vice versa. Roadside vegetation can improve the visual quality of scenic and other highways by screening unsightly views such as clear cuts, powerlines, junk yards, etc.

Edge Conditions. The edge condition of the roadside can affect visual quality of the highway in a number of ways. A strong contrast between trees shrubs and grasses can create visual interest along the length of a roadway corridor, as well as a unifying element, particularly in urban areas. In natural environments, a softer less defined edge condition can help blend the roadway with the surrounding plant communities.

Visual Consequences of Maintenance Techniques

Visual impacts of vegetation management can vary with the type of technique, frequency, and the time of year in which maintenance activities are performed. These techniques will also vary with the different climate zones in Colorado. Where the growing season is longer, additional management activities are required to maintain roadside vegetation. Where natural areas occur along the highway, maintenance management activities that preserve, protect and enhance the natural qualities should be utilized. The goal of vegetation management along highways is to protect the structural integrity of the highway, to provide a highway that is safe and visually pleasing.

Chemical Techniques. Chemically treating undesirable vegetation will have almost immediate results. Exposed soils as well as dead, dying, or discolored vegetation along the roadside will have significant visual impacts, especially when the affected area is of appreciable size. Many chemicals are applied by spraying and may drift onto non-targeted vegetation, particularly on windy days. Spraying activities are also affected by air turbulence from vehicular traffic. The use of adjuvants mixed into the solution can minimize the amount of drift and thereby minimize the visual impact associated with drifting chemicals. Areas where chemicals will have little visual impacts are found in cracks and joints of paved areas. If allowed to persist, the roots of the vegetation may cause further cracking and reducing the visual quality of the highway.

Careful attention to time of application can greatly reduce the visual impacts. Herbicides applied in late summer or early fall would have less impact than if applied in the spring. "Brown out" from herbicides would accompany the natural leaf drop of deciduous plants. Visual impacts of sprayed areas can be diminished if time between spraying and revegetation is significantly shortened.

Selective Herbicides. Selective herbicides kill only targeted plants. The affected vegetation will turn brown and die, leaving the desirable plants to grow and eventually take over the affected area which in turn improves the overall visual quality of the affected area. The visual impacts of brown outs will increase as the number of targeted plants which are sprayed amplify. Some forms of selective herbicides, such as Krenite (effective only on certain broadleaf tree species), affect only the area in contact with the chemical, mainly the leaves and buds and are used as a substitute for mechanical pruning. These herbicides are applied during late summer when buds are hardening off to keep buds from sprouting in the spring. The visual effects of this form of herbicide is that the leaves will turn brown and fall off a little earlier than normal since the fall season would be just beginning. No fall colors will be produced by the affected plants, which can have a negative visual effect if done over a large area and on scenic routes. Visual impacts can be diminished if spraying is done in the fall when leaves are losing their color or after leaves have fallen.

Non-selective Herbicides. Non-selective herbicides affect all vegetation with almost immediate results. The affected plants turn brown and eventually die, leaving dead foliage or bare branches. The affected area will be subject to soil erosion during the rainy season if not revegetated or covered with mulch, such as bark. The visual impacts are greater as the size of the affected area becomes larger. Systemic herbicides will eliminate undesirable vegetation through direct contact and will dissipate after a few weeks allowing desirable vegetation to establish soon after.

Residual Herbicides. Some residual herbicides, such as soil sterilants, affect all vegetation causing the plants to turn brown and die. The chemical remains active in the soil up to a year preventing other vegetation from growing. The exposed soil will be susceptible to erosion if not revegetated or covered with mulch, resulting in reduction of the visual quality of the affected area. The extent of erosion depends on slope, soil, and weather conditions.

Pre-emergent herbicides prevent seed germination and thereby eliminates the sight of dead vegetation. However, new vegetation will not establish in areas treated by pre-emergents for months after treatment. If there is no existing vegetation the ground can be exposed to erosion and thereby impacting the overall visual quality of the affected areas.

Selected insecticides will not harm roadside vegetation and will kill insects that are affecting the vegetation, improving the visual character of affected plants. However, insecticides may kill other insects which control undesirable plants increasing the chances of unwanted vegetation to establish.

Growth Regulants. Growth regulants are often used in areas requiring frequent mowing and cutting to control the height of vegetation. Growth regulants reduce the need for other, more noticeable forms of vegetation management. By reducing the frequency of maintenance activities, impacts to the visual quality of the roadsides is then reduced.

Growth regulants can create adverse visual impacts through improper application. Excessive application can cause discoloration of foliage.

Cultural Techniques. Visual impacts from cultural maintenance techniques are not as conspicuous as most other methods since changes tend to occur over time. Existing vegetation is encouraged and enhanced to compete with undesirable species. The goal is to create a healthy plant community of desirable species which can withstand invasion from other plants which in turn will improve the visual quality of the affected area.

Selective Pruning. Selective pruning of trees and shrubs by hand involve cutting portions of or entire branches and if done properly the plants natural form can be preserved or enhanced can by removing diseased and unsightly vegetation and thereby enhance the visual quality of plants. Selective pruning can allow sufficient sunlight to penetrate the understory which support other desirable vegetation. The visual quality of plants can be destroyed by selective pruning if branches are cut arbitrarily without regard to the natural form of the plant or by not cutting branches flush with the main stem, leaving unsightly stubbles.

Competitive Planting. Desirable competitive trees, shrubs, grasses, and forbes are introduced to compete with and help control the spread of undesirable plants. The selection of competitive vegetation needs to be scrutinized to avoid adverse impacts such as the elimination of desirable plants, invasion of adjacent properties, and roadside encroachment.

Hydroseeding is an effective method of introducing competitive vegetation which will provide a vegetative cover for disturbed areas over a short period of time to discourage undesirable plants from establishing and prevent soil erosion and thereby minimizing visual impacts of affected areas. The addition of wildflowers can improve the visual quality of disturbed areas which provide a variety flowers during the spring, summer and fall months. Some forms of wildflowers, such as legumes provide nitrogen fixing capabilities in soils which can increase the available nitrogen in the soil and thereby improve the growing conditions and visual quality of desirable plants. This is a good method of preparing an area lacking in nutrients for establishment of desirable vegetation. Common legumes found in wildflower seed mixes include clovers, trefoil, wild pea and lupines. Wildflowers also provide deeper root systems to provide better soil holding capabilities to prevent soil erosion on steep slopes.

Irrigation. Precipitation is an important factor in determining which plant species can be planted in Colorado. Irrigation systems expand the diversity of available plant species for use in roadside planting. Irrigation can improve visual quality by enhancing plant vitality during the dry summer months and is commonly used where ornamental or non-native plants are utilized. Irrigation can dramatically improve visual quality, particularly in urban locations and in areas where public use is high, such as rest areas. Improper watering of vegetation through insufficient or over watering can cause plants to become unhealthy making them susceptible to diseases and lead to their demise. Over watering can cause soil erosion on sloped areas and impacting the overall visual quality of the affected area.

Other Techniques. Fertilizers can have direct positive influence on targeted plants by improving growing conditions and thereby providing healthier looking plants. The method of application of fertilizers will also affect the visual quality of plants. Excessive applications of fertilizers can burn plant materials, thereby diminishing the visual quality of the plants.

Adding organic mulches to the soil can improve growing conditions, such as increase the moisture holding capacity and control temperature fluctuations in the soil, and improve plant vitality. This results in healthier looking plants. Organic mulches, such as bark mulch, are used to reduce the possibility of soil erosion on sloped surfaces. Bark mulch, in itself, can improve the visual quality of disturbed areas whether the area is vegetated or not and is commonly used in urban and suburban areas. Mulch derived from leaves, wood fibers and grass clippings are utilized in rural and natural areas, such as agricultural and forested areas which visually harmonizes with the surroundings.

Biological Techniques. The use of biological techniques to eliminate undesirable vegetation can adversely affect the visual quality of roadside vegetation. Insects or plant diseases are introduced into a plant community to reduce or eliminate the population of targeted vegetation. Host plants usually will show effects of the treatment over a long period of time and eventually die. Some host plants may not die, but will be greatly weakened which can initially reduce the visual quality

of the affected area. The long term effects would be the establishment and replacement of desirable species within one or two years and thereby improving the visual quality.

Mechanical Techniques. Mechanical techniques involve cutting, shearing and blading to reduce or eliminate undesirable vegetation. Visual impacts may vary depending on the time of year the practice takes place and which technique is utilized. Mechanical equipment can damage visual quality through improper and inappropriate use.

Brush Cutting. Small trees, shrubs, and other vegetation are removed with large brush cutters, or by hand methods. Small scale brush removal may have only minimal visual impacts since much of the nearby vegetation is preserved. For large scale removal, exposed soils and cut stems can be visible until grasses and other low vegetation become established. Removal of unattractive brush can improve visual quality.

Brush Shearing. Shearing equipment are used to keep vegetation from encroaching onto the highway and shoulders and keep drainage courses operational. This method can expose trunks and stems which are easily visible along the entire affected area. Some branches and trunks are not cut cleanly and portions of bark are torn off exposing the lighter wood beneath. Large mowers or brush cutters trim all vegetation to the ground exposing unprotected soils. The cut branches, trunks, and foliage are left in place to decompose and return to the earth which in turn protects the soil from erosion. The cut material is visible until new vegetation begins to grow. The visual impacts will vary depending on the size of the vegetation and time of year when cutting is performed. Larger vegetation which have been cut will expose larger size cuts and tearing of bark. Some varieties of brush that are cut in this manner will produce resprouting of more branches creating a thick matt of branches which is unnatural in appearance and destroys the natural character of the vegetation. This appearance may be suitable in urban and some suburban locations where shearing of vegetation is common, but will appear out of place in rural and natural areas. Plants that can propagate from cuttings can multiply rapidly from pieces that remain on the ground after the cutting operation. The area will soon become overcrowded with plants, increasing the competition for water, nutrients and sunlight resulting in stunted growth and the demise of weaker vegetation and reduction of the overall visual quality. The visual impacts are greatest soon after cutting when the cut portions are distinctively visible. The effects of cutting, when done during early spring, will be covered by new growth within a month. If the cutting is done during the fall, the sheared appearance will be visible throughout the winter months since no new growth will appear during this period.

Tree Thinning. Tree thinning comprises of selective removal of stands of trees or individual trees. Removal of stands of trees can diminish the visual quality of the affected area significantly, particularly to viewers who are familiar with the area. Removal of large stands of trees exposes vegetation adapted to shady conditions to direct sunlight becoming vulnerable to sunburn and dryer soil conditions. Plants in this situation often turn brown and die, adversely affecting the visual quality. Most thinning processes involve the removal of selected trees within a stand of trees to improve growing conditions and to allow desirable plants to establish. This method will show little disturbance since most of the surrounding vegetation is left intact and minimal visual impacts.

Mowing 6" High. Mowing equipment used to remove grass and low growing vegetation along roadsides can provide a manicured appearance, help define the highway area, and improve visibility along the corridor near curves, intersections, and urban areas. Mowing grass at six inches is appropriate for urban and suburban areas and service areas such as rest areas and bus stops where a manicured appearance would blend in with the formalized landscape treatment. Frequent mowing can improve the visual quality of lawn and grass areas. However, this method may appear out of character in rural and natural or sensitive areas. The cut material is usually left in place and can be unsightly until it is concealed by new growth. However, leaving the cut grass in place provides a mulch which will diminish the amount of water loss in the soil through evaporation and thereby requiring less watering and healthier looking grass over a longer period of time during drought seasons.

Unmowed Grass. Grass left unmowed provides a natural meadow which would be visually appropriate in rural and natural areas, but out of character in urban and suburban areas.

Other Techniques. Blading is effective in removing vegetation from shoulders and drainage swales. However, blading exposes soils to establishment of undesirable vegetation and potential erosion. Ditches which have naturalized will appear stark after the vegetation has been completely removed.

Unavoidable Adverse Impacts. Views of maintenance equipment along roadsides will have temporary visual impacts to those utilizing the highway as well as to adjacent properties who have views of the highway corridor. The degree of visual impacts will change from urban areas to natural areas. Urban areas exposed to numerous vehicles and therefore will have very little visual impacts. Natural areas will have the greatest visual impacts by maintenance equipment since it is a foreign element within the landscape.

Initial results of vegetation management activities may have visual impacts until the vegetation has had an opportunity to fill in or recover from the effects of maintenance management activities.

VIII. CONTROL OF NOXIOUS WEEDS

The following section provides a comprehensive description of how to develop and implement a weed management plan, and presents specific control measures for Colorado's four designated weeds. Each maintenance section should identify and train a weed manager who would be responsible for customizing the area's specific weed management and herbicide needs.

STATEMENT OF THE WEED PROBLEM

A "weed" can be defined as a plant that meets any of the following criteria:

1. any plant that grows where you don't want it;
2. any undesirable plant that crowds out desirable plants;
3. any useless, troublesome, or noxious plant, especially one that grows profusely;
4. any plant that is objectionable or interferes with the activities or welfare of man or animals; or
5. usually a non-native plant species that causes disease or has other adverse effects on man or his environment and therefore is detrimental to the agriculture and commerce of the United States and public health.

A "noxious plant" is an alien plant species or parts thereof which meets one or more of the following additional criteria:

1. It aggressively invades or is detrimental to economic crops or native plant communities;
2. it is poisonous to livestock;
3. it is a carrier of detrimental insects, diseases, or parasites; or
4. it is directly or indirectly detrimental to environmentally sound management of natural or agricultural ecosystems.

The following are identified as undesirable and noxious plants in the State of Colorado under the Colorado Weed Management Act (H.B. 90-1175) of 1990:

1. Leafy spurge;
2. Russian knapweed;
3. Diffuse knapweed; and
4. Spotted knapweed.

The control of these weeds throughout the state must be considered a top priority. The Colorado Weed Management Act also allows individual counties and municipalities to declare additional

weeds as undesirable within that county. These are usually weeds that have a significant impact in that location. A list of all undesirable plants within each county can be found in Appendix E.

INTEGRATED WEED MANAGEMENT

Integrated Weed Management (IWM) is a process used to address alternatives for control of undesirable vegetation. These alternatives are considered with regard to their predicted ecological, sociological, and economic consequences. A course of action is determined and implemented following the guidelines developed in the IWM plan. It utilizes all facets of vegetation management, including prevention and mechanical, biological, cultural, and chemical controls. The IWM program seeks maximum use of natural measures, especially biological diversity, competition, and plant succession. The plan must be allowed to evolve and change with the surroundings and circumstances around which it is based.

ESTABLISHED INFESTATIONS: CHOOSING APPROPRIATE GOALS AND STRATEGIES

When dealing with established infestations of noxious weeds, whether containment or suppression strategies are chosen will depend upon the damage thresholds of the targeted noxious weed species. Damage thresholds will vary according to species-specific and site-specific factors. When determining damage thresholds, for the purpose of selecting a containment or suppression strategy for an established infestation, the following factors should be considered:

- Clearly determine the management goal(s) of the site.
- Identify the specific established species on the site.
- Identify the population size and rate of spread.
- Identify the successional stage of vegetation on the site. For example, is the site moving toward climax, or an earlier successional stage.
- Identify whether or not the infestation is benefiting the site in some way (e.g., preventing erosion, building topsoil, providing food for wildlife or pollinating insects, etc.).
- Identify population dynamics of the targeted weed species. For example, will weed population levels decrease, or will they persist even after the natural vegetation returns to predisturbance levels?
- Identify any special land resources that need to be addressed which could be affected by spread or type of treatment (e.g., threatened or endangered species, wildlife habitat, etc.).
- Identify the likelihood of success measured against the cost of a control program.
- Identify the long-term and short-term cost of no action.

ESTABLISHED INFESTATIONS

The key to managing established infestations is to prevent the conditions which allow weeds to spread into areas not currently infested. The goals are containment and/or suppression, depending on the damage and action threshold for the site and weed species being targeted. The damage and action threshold also determines what strategies are the best for a given situation. This manual identifies five strategies from which to choose: Prevention and Mechanical, Biological, Cultural, and Chemical Controls. Prevention is the preferred strategy.

Containment means to confine a specific weed species to a geographical area. When considering containment as an option for an established infestation consider which species on which sites are causing or are likely to cause unacceptable offsite movement/damage. Once this is determined, sites can be prioritized according to the amount of off-site damage, if any, that can be tolerated.

On sites where unacceptable off-site damage is already occurring (i.e., the damage threshold is exceeded), prevention, correction, and mitigation strategies are employed to bring the weed species below the damage threshold. Prevention strategies should be implemented for all areas where the targeted weed species has not yet occurred.

ESTABLISHED INFESTATIONS: SUPPRESSION, MAINTENANCE, AND NO ACTION

Suppression is defined as reducing a weed population without the expectation of control (prevention of all seed production) or containment (confinement to a specific geographical location). In this instance, damage and action thresholds are often close, and the population dynamics of the weed(s) in question are well understood.

"Maintenance" and "No Action" strategies support the current condition of the site. The strategy of "No Action" means that no activity interfering with natural processes on the site will be taken. The strategy of "Maintenance" is similar to the "No Action" alternative in that it supports the current condition of the site. In "Maintenance" situations, suppression tactics, such as release of biological control agents or mowing, are often appropriate.

No Action Strategy Examples

Russian thistle is identified on a three-year old, abandoned rangeland site. The population is moderate and concentrated where dozer piling and burning were employed for oakbrush control. Roads to the site have been closed, and it is several miles to the nearest road. Analysis reveals that grasses on the site appear to be growing as well as grasses on a similar unit where Russian thistle is not present. Research suggests that Russian thistle is cyclic in a rangeland environment, and that without major disturbance, population levels will naturally decrease as the grasses regenerate. Evidence also suggests that the weed is not capable of developing dense stands for extended periods of time. In light of these factors, it is decided that there is no evidence to support a prediction that Russian thistle will exceed the damage on this site, and the "No Action" strategy is selected.

Another appropriate example of the "No Action" option would be if a landowner adjacent to the highway had a major infestation of noxious or undesirable plants growing unchecked. CDOT will

not perform control measures on the adjacent section of highway right-of-way to prevent the waste of funds on unsuccessful control.

Maintenance Strategy Example

During site analysis for a planned state roadway, a small isolated infestation of leafy spurge (*Euphorbia esula*) is found along the planned roadway site. Access to the site is currently limited, and the roadway is still in the planning stages. The infestation does not pose a threat of invasion to private or county land. In order to support the current condition of the site, a decision is made to release a biological control agent, (*Aphthona nigriscutis*). This agent is expensive, usually available for purchase, and has demonstrated that it will suppress leafy spurge and will most likely overwinter in areas similar to the target site.

TREATMENT STRATEGIES

A strategy is an overall approach to a problem, such as using "habitat management" to suppress a weed. A tactic is a specific action or series of actions within that strategy. For example, reseeding immediately after new road construction is a tactic that might be part of the strategy of habitat management for spotted knapweed.

CRITERIA FOR SELECTING TREATMENT TACTICS AND DEVELOPING WEED MANAGEMENT STRATEGIES

Once the IWM decision-making process is in place and the decision is made to use a weed control tactic, the choice of actual strategy and tactic can be made. Control strategies should meet the following criteria:

- Most likely to permanently remove unwanted species;
- Most likely to reduce or eliminate habitats for recolonizing noxious weeds;
- Least disruptive of natural controls;
- Least hazardous to human health and the environment;
- Easiest to implement and carry out effectively; and
- Most cost effective in the short and long term.

Using these criteria will maximize the long-term effectiveness of control tactics and minimize adverse impacts on non-target organisms.

SUMMARY OF TREATMENT STRATEGIES

A weed management strategy is a group of planned tactics or methods for preventing or controlling weed populations. When dealing with noxious weeds, management strategies are based on ecological understanding. The Integrated Weed Management concept is predicated on the fact that combined strategies for weed management are more effective in the long run than a single strategy.

All weed control methods can be described as having one of two basic effects on the weed population: direct or indirect. A direct method or tactic focuses on the weeds themselves, e.g., applying herbicides, handpulling, etc. Indirect methods focus on the environmental and social aspects of the weed problem in an attempt to enhance the effect of natural controls on the weed, to modify human maintenance activities or attitudes, or otherwise modify the life support system of the weed.

INDIRECT CONTROL (Prevention)

Habitat Modification or changing the biophysical environment for purposes of:

1. Reducing weed habitat requirements e.g: by not scalping ditches with mowers;

2. Enhancing the environment required by the weed's natural controls.

Human Behavior Changes

1. Not parking or camping in weed infested sites;

2. Not using weed contaminated gravel or soil.

Land Management Activities

1. Encouraging use of weed-free hay and seed;.

2. Installing woven wire fence to prevent noxious weeds from being blown onto joining property;

3. Refrain from disturbing soil without immediate revegetation, including construction practices, and state road maintenance.

Education

1. Modifying judgments about the influence of weeds and management on the environmental quality of public lands;

2. Nurturing an environmental ethic concerning noxious weeds;

3. Developing an ecosystem approach.

DIRECT CONTROL

Mechanical Controls

1. Manual (hand pulling, digging, cutting);

2. Mowing;

3. Cultivating;

Biological Controls

1. Importing and releasing host-specific natural enemies (insects, nematodes, etc.);

2. Conserving the weed's natural controls through proper selection of materials, timing, placement of materials, and grazing with sheep and goats;

3. Augmenting the introduction of additional numbers of the weed's natural enemies at a critical time.

4. For more information on specific biocontrol measures, see Division of Plant Industries, Annual Report.

Cultural Controls

1. Reseeding disturbed soil using CDOT's "Erosion Control and Storm water Quality Guide."

2. Using fertilizer;

3. Implementing grazing management systems and no 4x4 or off road vehicles.

Chemical Controls

1. All applicators of restricted pesticides will be commercially licensed by the State of Colorado in the industrial and rights-of-way category;

2. Applicators shall use personal protective equipment in accordance with the occupational health program;

3. Spot-apply herbicides (selective and nonselective) according to the label plan;

4. All local Fire Departments will be notified when spraying in their area;

5. Follow up treatments to prevent reinfestation and extensive retreatments.

6. The public will be notified of specific spray areas.

PREVENTION

Prevention of situations that require direct control of noxious weeds is the primary emphasis of this section of the manual. Prevention is defined as the process of forestalling the contamination of an area by a noxious weed.

Prevention means to detect and resolve the conditions that cause or favor the presence of competing or unwanted vegetation in the area. Prevention is in contrast with treatment that refers to activities for controlling infestations of competing or unwanted vegetation. It also should not be confused with early treatment, which refers to activities for controlling or eradicating initial, small infestations of competing or unwanted vegetation before they interfere with the objectives for managing that area or adjacent lands.

Prevention includes the measures taken to forestall or hinder the introduction and spread of specific plant species in areas not currently infested with those weed species. Such areas may be local, countywide, or even statewide in scope, as in a Certified Weed Free Hay Program.

IMPLEMENTING PREVENTION STRATEGIES

Implementing prevention strategies means to:

- analyze the risk of noxious weed invasion before spread;
- develop tactics to avoid introduction of noxious weeds before land management decisions are made and actions taken.

To the degree that the environment for noxious weed invasion and spread can be reduced or eliminated at the time land management activities begin, the need for ongoing weed control strategies can be kept to a minimum.

PREVENTION TACTICS

The following measures should be followed when implementing prevention strategies:

- Construction practices should be conducted so disturbance takes place only on lands that will be revegetated or built on immediately
- Encourage use of steam cleaned equipment for road building and other construction.
- Require clean gravel and fill material with a voluntary annual inspection of pits.
- Use certified weed-free seed for plantings.
- Reseed immediately in disturbed areas to provide competition.

- Use a seed mix for all revegetation work that provides dense vegetation on disturbed sites according to the erosion control plan with the addition of other varieties/species of grass according to university research and Soil Conservation Service recommendations.

- Do not use weed infested sites for equipment storage sites.

- Clean maintenance equipment before moving it to new sites in order to minimize the transportation of noxious weeds to uninfested areas.

- Consider controlling the animal feed in the State by encouraging the use of the Colorado Weed Management Association's weed-free hay production and sales program to reduce the risk of noxious weed introduction.

- For at least five years, newly constructed roads should be surveyed and monitored for noxious weed species.

- Conduct a noxious weed survey of existing roads. Those segments that are currently free of noxious weeds should be treated as new construction.

- Monitor, on a regular basis, likely locations where new invaders are apt to occur outside designated containment lines.

MITIGATION

Mitigation is a process whose intention is to eliminate, minimize, rectify, or reduce the impacts of noxious weeds in currently infested areas.

> NOTE: Major emphasis is given to development of strategies that consider techniques that are permanent or non-toxic (indirect controls). Note that many of these strategies are similar to prevention tactics. The main point of differentiation between prevention and mitigation is whether or not designated weeds are present or absent from the site.

Example: Closing a new park immediately after construction until new grass gets established is prevention if there are no noxious weeds on the unit prior to closure. However, if noxious weeds were present on the site prior to construction, the action of closure would be considered a mitigation measure.

MITIGATION TACTICS

- Make noxious weed mitigation the highest priority for weed division funds.

- For at least five years, newly constructed roads should be surveyed annually and all noxious weeds controlled before seed production occurs.

- Revegetate disturbed areas immediately, using a mix of species to provide competition on disturbed sites according to CDOT's "Erosion Control and Storm water Quality Guide" recommendations. Develop a seed/fertilizer package to be used on sites where noxious weeds have been treated. This package could be made available at cost to employees, volunteers, and the public.

SELECTION CRITERIA

Selected control measures must satisfy four criteria:

1. Proven Efficacy
2. Lowest Environmental Impact
3. Operationally Feasible
4. Cost-Effective.

EDUCATION AND AWARENESS

Public education and awareness programs are essential to reducing the possibility of invasion and establishment of potential undesirable plants. Employees of the State and landowners must learn to recognize when a potential invader is present and know what to do about it when found or thought to exist.

Objectives

1. Begin gathering initial information on each prioritized species, such as:
   - Who knows about the plan?
   - What is the biology of the weed and what (if any) natural controls exist?
   - What is the biology of the ecosystem surrounding the weed?
   - What kind of surveys have been performed? What level of survey methodology should be applied to each species?
   - What are the likely methods or vectors by which each designated species may be transported into the County?
   - Have non-chemical management techniques been emphasized?
   - Should chemical tools be considered to quickly control an initial outbreak?

2. Initiate a weed identification and recognition program for certain State employees. Hold educational programs annually and require attendance. The extension service has developed a weed identification program that is recommended for use.

3. Expand the present program for in-service training and involvement to reach more employees of the State, including tree planters, stand examiners, volunteers and cooperators.

4. Obtain herbarium specimens and display in public areas at the Weed District Offices.

5. Enlist the aid of and further develop programs with landowners and Federal, State, Municipal, and County agencies to inform people about preventing infestations, monitoring likely locations where weeds first show up, proper reporting procedures, and what action(s) to take when potential invaders are found.

TACTICS

1. Train in-service people and the public, including, tree planters, silviculturalists, road builders, maintenance people, and volunteers, to recognize, take action, and report noxious weeds of concern.

2. Obtain and/or prepare educational materials such as noxious weed alerts, brochures, fliers, etc. to acquaint people with noxious weeds and the impact of their spread. Distribute materials to State personnel and newspapers.

3. Require that all permits issued for development on State lands include an alert about noxious weeds.

The remaining topics in this section outline how to develop a specialized Integrated Weed Management Plan (IWM). These ideas are provided as reference material for maintenance supervisors, designated weed specialists, or other interested parties. The development of an IWM is not required by CDOT policy, however, time and funds permitting, the remainder of this section could serve as a blueprint for creating and implementing regionally specialized IWM plans.

EVALUATION

The term "Integrated Weed Management (IWM)" means that all possible tactics used to affect the noxious weed population are combined into a systematic approach to the problem. Integration also means the smooth interaction of all components outlined in this document to achieve the program's ultimate purpose: a coexistence between humans and noxious weeds that is satisfactory to the people involved and does not threaten the survival of the environment, of which both humans and weeds are a part.

Evaluation is important to gauge the success or ineffectiveness of treatments, identify impacts on non-target organisms or other resources, determine true costs, and allow for adjustments in the project, if needed.

For purposes of overall evaluation, it is helpful to regard the IWM program as being composed of many simultaneously occurring interactive systems or processes, including:

- monitoring
- record keeping of field data
- decision making regarding prevention and action activities
- treatments
- treatment evaluations
- collection and cataloging of reference materials on management of targeted weed species
- training of maintenance personnel
- education of agency personnel
- communication to agency personnel and the public regarding program particulars and progress
- budgetary planning
- evaluation of the overall IWM program.

Each of these components should have, as part of the development of the initial program plan, expressed objectives or criteria by which the component is judged successful or not. In addition, questions must be asked: Were all the necessary components to the program actually developed? Were the components integrated successfully? Were the right people involved in the integration of the components into a whole program?

Criteria must be established to review progress annually toward reducing reliance on herbicides. Record keeping must be established that would keep track of:

- Annual estimated acres infested with each target species;
- Annual total acreage of all weed species combined;
- Annual number of acres treated with biologicals;
- Annual number of acres treated by mowing;

- Annual number of gallons of herbicides used;
- Annual number of acres treated by herbicides; and
- Annual number of acres treated by other methods.

Using the above information, the State would have the baseline data necessary to determine:

- Percent of treatment projects that require herbicides;
- Percent of treated acres that require herbicides;
- Percent of treatment projects that require prescribed burns; and
- Percent of treated acres that require other methods of control.

Compared annually, this data would demonstrate the State's progress toward reduction in use of herbicides.

TRANSFERRING THE TECHNOLOGY

Information on the strategies and tactics to be employed, as well as the methods by which they are integrated into the ongoing program, must be disseminated to others who will be directly or indirectly involved. Some of the information may be totally unfamiliar to the recipients and at times may even appear to be contrary to their current practices. The study of the process of technology transfer in general provides some helpful insights into what might be expected when IWM concepts and techniques are introduced within an agency.

Several stages have been identified in situations where new technologies or innovations are adopted:

1. AWARENESS of the new technology;
2. INTEREST in it;
3. ASSESSMENT of its utility;
4. TRIAL;
5. IMPLEMENTATION.

Awareness levels may be raised by employing:

- Information tools of many types (magazine and newspaper articles, books, research papers, lectures, discussion sessions, etc.);

- Information media that is intrinsically interesting (films, slides, cartoons, games, etc.);

- Sustained information delivery (newsletters, regular memos, bulletin boards and displays, study groups, etc.).

Awareness alone does not lead to technology adoption, but among people who might be characterized as "early adopters" interest is aroused.

Interest leads to a desire to learn more about the technology. At this point, people want in-depth case histories of successful application and contact with people who have used the new technology successfully.

Assessment by the State means examining the new technology to see if it appears:

- Effective;

- Cost effective over short and long term;

- Flexible (can be tailored to the unique circumstances of the county);

- Simple;

- Sustainable;

- Preferred (preferred among comparable activities or options); and

- Compatible (with existing values, past experiences and other needs).

Trial and Implementation of the new technology requires that the description of the process to be followed is broken down into the smallest possible steps. Because Integrated Weed Management is essentially a decision making process, it can be helpful to utilize decision trees, flow charts, etc.

MAINTENANCE AND INSTITUTIONALIZATION OF IWM

Maintaining the new system within the State once the original design and implementation teams have moved onto other things may be difficult. Institutionalization of the IWM process may require the conscious reinforcement of positive incentives.

The person(s) chosen as IWM designer/coordinator would prepare, in written form, a complete description of the program as it should be maintained. Ideally, this should exist in two versions: one for supervisors and one for field personnel.

When developing information for field personnel, the following should be included:

- The overall IWM process for managing each target species;

- Biological and ecological information on the weed and its natural enemies;
- The surveying and monitoring system for the target weed and its natural enemies;
- The monitoring system for cultural and other maintenance activities that indirectly affect the target weed species;
- The record keeping system to be used;
- How to interpret summarized displays of field data;
- The tools required in carrying out monitoring and treatment activities, and how to use, obtain and maintain these tools;
- The range of treatment tactics desirable for use against the weed and how to employ them;
- How to evaluate their performance and the effect of the treatment actions;
- Where to get further information.

Photographs, drawings, tables, Cooperative Extension weed bulletins, pertinent Federal documents, etc. should all be included.

IWM STANDARD OPERATING PROCEDURES

The implementation of an integrated weed management program considers the use of many different weed control procedures, including prevention, mechanical, biological, cultural and chemical controls. The following management priorities have been established:

Priority 1: Take appropriate actions to minimize the need for weed management when and where feasible.

Priority 2: Use effective nonchemical methods of weed management when feasible.

Priority 3: Consider the use of all control methods, including combinations of methods before considering the sole use of herbicides.

An initial program should include a three-year trial period which prohibits wholesale spraying along a right-of-way. Only spot treatments directly on weed infestations will be considered. Non-infested areas would not be chemically treated. Upon the request of a landowner with land adjacent to state land, spraying will not be done next to his/her property (See information on CDOT's Adopt-A-Highway Program).

The major goal is to avoid unnecessary chemical retreatment. Follow-up measures will be required to prevent re-infestation. A spraying program must be called into question if these preventative measures are not performed. People opposed to herbicide use may formally register with their

county. Each county must inform the State of those registered. No chemical sensitive registration with the state will be needed. This may be included in the Adopt-A-Highway program. The State will provide the necessary markers to prevent treatment in these areas along State rights-of-way.

The main objectives of this policy are to:

1. Minimize risks to the general public, state/county employees, and contract workers; and

2. Meet legal mandates for public lands and services.

SELECTION CRITERIA FOR TREATMENT METHODS

Land treatments will be considered to meet vegetation management objectives of an area, such as development and modification of the desired plant community, or serial stage, biological diversity, removal or reduction of undesirable species and control of noxious weeds, and maintenance of all resources present. The method of treatment to be used shall be determined by several factors such as human health, environmental impacts, safety, project longevity, effectiveness of practices in meeting objectives, technology available, and cost effectiveness.

As technology improves and more biological control agents are tested and proven effective, it is the State's goal that herbicide use will decrease for the control of noxious weeds. However new spot infestations will most likely continue to be treated by mechanical or chemical methods where complete elimination is the goal.

The cost-effectiveness of each treatment will be a major consideration in selecting the treatment method. A lower cost per acre is normally achieved when individual projects are consolidated into one contract. This consolidation reduces the cost of equipment moving to and from the job site. Cost alone will not be the sole determining criterion, but will be considered together with environmental impacts and available technology. Environmental impacts may be the main criterion in the future. Some treatments may be cooperatively planned with other agencies or adjoining landowners in order to take advantage of sharing workforces and lowering the cost of treated areas.

PROGRAM SIZE AND SCOPE

The size and scope of the weed management program depends upon the rate of spread of noxious weeds and undesirable vegetation. This cannot always be accurately predicted. Treatment goals and budget constraints will also have an effect on the methods of treatment.

The focus is to utilize the best combination of available treatment methods under an IWM approach to treat undesirable plants or noxious weeds targeted for control, given the affected environment and its conditions, resource impacts involved in treatment, and related costs, including human health and safety.

Ongoing Search for Alternatives

The operational feasibility of new research findings on alternatives for IWM should be evaluated. The exploration of new ideas for prevention and treatment of weed problems will be encouraged through such cooperative research units as the Colorado Department of Agriculture Insectary, Colorado State University, and other universities throughout the Rocky Mountain Region.

Additional Environmental Review

The environmental review of site treatment plans (including application of categorical exclusions where appropriate) will be conducted by a CDOT environmental specialists and will focus on resources that are unique to the specific sites. This will be done during site specific analysis and documentation as outlined on the noxious weed treatment checklist.

All additional analysis will be based on guidance from the environmental specialist. If a potential for significant impacts, not already described, is discovered, further consultation should result.

PROPOSED ACTION

All methods of treatment - mechanical, biological, cultural, and chemical would be available to treat weeds under the proposed action. This is the most flexible alternative when compared to individual control measures because it would allow implementation of the most effective treatment method on each site.

DECISION RATIONALE

Biodiversity is one of the desired goals of the undesirable vegetation management program. Achievement of this goal requires a flexible approach designed on a site-specific basis. Encroachment of the designated species cannot be contained with any one method alone. The proposed action provides the flexibility to tailor the treatment to the environment, and therefore, is the environmentally preferred alternative. To do otherwise would negate the ability to reach management goals.

PROGRAM IMPLEMENTATION FEATURES

In planning for site-specific treatments the following should be analyzed:

1. Predominant weed species in the project area.

2. Predominant non-target plant species in the project area.

3. Consideration of all feasible weed management alternatives, including:

    - Identification of environmental effects on fish, wildlife, soil, ground and surface water, air, rare or endangered plants and animals, nontarget plants and culture sites.

- Identification of human health hazard(s) associated with each method. The safety of the general public, and employees and contractors of the state will be a primary consideration when proposing treatments.

- An analysis of the effectiveness of each method and retreatment needs.

- Control of noxious weeds required by law will not be subject to a benefit-cost analysis; however, the most economical and efficient method will be analyzed along with the risk of the proposed kind of treatment.

- The cost of each method regarding hazards to non-target species.

- Geographic Information Systems (GIS) maps, including soil and weed overlays, will be used when available. Contact Doug Lang, CDOT, for an overview of CDOT's existing GIS.

- Identification of growth characteristics, sensitivity to treatment method, stage of growth, life span, etc. of both target and nontarget plant species at the time of treatment.

4. Recommended treatment method(s), or combination of methods.

5. If herbicides are to be considered, the following additional information is required:

   - A completed noxious weed treatment checklist for the project area.

   - Preventive measures planned to impede reinfestation.

   - Monitoring of the project area.

PREVENTION

If new infestations can be identified and eliminated at once with shovels or hoes, then a serious problem can be prevented. Do not buy and plant infested seeds. When driving into an infested area, do not drive through the weeds, and clean off the vehicle before leaving the site if contact was made with noxious weeds. The greatest challenge is educating the public. Education is the primary prevention tool.

CULTURAL

Reseeding

CDOT's "Seeding Manual" provides guidelines for reseeding. All seed purchased for reseeding shall be tested and certified noxious weed free prior to purchase. Any seed containing noxious weed seed will be rejected. Seed mixtures and procedures will be determined from university research or SCS on competitiveness with noxious weeds and biological diversity, soils and ecology

of the individual site. CDOT's "Erosion Control and Stormwater Quality Guide" and SCS specify other criteria that will be followed by the State.

Detailed information on recommended planting times, grass varieties, and seeding rates can be found in CDOT's "Seeding Manual".

BIOLOGICAL

Biological control is still in its infancy and much research remains to be done. Any introductions of biological control agents will be in compliance with United States Department of Agriculture, Animal and Plant Health Inspection Service and Colorado Department of Agriculture's, Division of Plant Industry guidelines. Biological methods of treatment employ living organisms to selectively suppress, inhibit, or control herbaceous vegetation. This method is viewed as one of the more natural processes because it requires the proper management of plant-eating organisms and precludes the use of mechanical devices or chemical treatments of undesired vegetation.

The use of biological control agents will be conducted in cooperation with the Colorado Department of Agriculture's Insectary in Palisade, Colorado. Insects, pathogens, and grazing by sheep or goats would be used as biological control methods under all alternatives. Biological control is a long-term method.

Insects are the main natural enemies being used at the present time. Other natural enemies include mites, nematodes and pathogens. This treatment method will not eradicate the target plant species but merely reduces the target plant densities to more balanced and possibly tolerable levels. This method also reduces competition with the desired plant species for space, water and nutrients. This treatment method will be used on larger sites where the target plant has become established and is strongly competitive.

Generally, biological methods using sheep or goats, are used in areas of compactible soils and could be used on erosion hazard areas, riparian areas susceptible to bank damage, and steep erodible slopes as long as over-grazing did not occur. Sheep or goats would be used in treatment areas for short periods. This is not a feasible treatment alternative for roadside vegetation maintenance.

To develop a biological weed control program, the following steps must be taken:

1. Identify weed species and determine origin, normally performed by USDA's Rangeland Weeds Laboratory (RWL).

2. Find any natural enemies occurring at the point of origin (performed by RWL.)

3. If possible, release biological control agents for the first time onto selected sites.

4. If biological control agents survive and increase in numbers, collect agents and release onto other sites of weed infestation.

According to Norm Rees, USDA Agriculture Research Service Scientist at the Rangeland Weeds Laboratory, Biological Control of Weeds Research Unit, Bozeman, Montana, usually a complex of at least three to five different biological agents, such as insects, must be used to attack an individual weed infestation site to achieve desired results. A complex of biological agents is the long-term goal for each weed. Five years or more are needed to bring about an economic control level, especially on creeping perennials. Usually, biological methods using ungulates would avoid erosion hazard areas, areas of compactible soils, riparian areas susceptible to bank damage, and steep erodible slopes.

MECHANICAL

Mechanical or manual treatment is often more desirable (especially when used on a new infestation) and will be used to the extent of practicality and availability of funding and work force. The best mechanical method for treating undesirable plants in a particular location depends on the following factors:

1. Characteristics of the undesired species present (for example, density, stem size, brittleness, and sprouting ability);

2. Need for seedbed preparation and revegetation;

3. Topography and terrain;

4. Soil characteristics (for example, type, depth, amount and size of rocks, erosiveness, and susceptibility to compaction);

5. Climatic conditions; and

6. Potential cost of improvement.

Periods of mechanical (mowing) treatment should avoid the bird nesting season and other critical seasons when loss of cover would be critical to wildlife; e.g. during critical reproductive periods and prior to severe winter weather conditions. Mowing should also be avoided before seed production of natural wild flowers is complete.

Generally, mechanical treatment would avoid areas of high slope; areas where revegetation potential is low; areas frequently impacted by high precipitation events; and areas having high potential for compaction. Soil disturbing activities (like road construction) would be perpendicular to the slope, where possible, to reduce concentrating the water and increasing erosion.

HERBICIDE TREATMENTS

Approved herbicide formulations can be found in the *Colorado Weed Control Handbook.*

PERSPECTIVE ON METHODS

Herbicidal chemicals must be registered by EPA under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). To be registered for commercial sale and public use, herbicides must provide specific economic and social benefits. In order for herbicides to be registered by the EPA under FIFRA, the chemical preparation must not pose "an unreasonable risk to human health or the environment."

The public may call a hotline that describes when and where all upcoming CDOT spraying activities will be performed and will include daily updates. Beekeepers will also be notified in like manner. The "DO NOT SPRAY" (adopt-a-highway) persons should have a chemical free buffer of 5 ft. on either end of their designated area. Efforts should be made to inform Adopt-A-Highway personnel that it is important that they call this number prior to performing their roadside cleanups.

Additionally:

1. Pesticide Labels will be read by the applicator before purchasing, before mixing and loading, before disposing of the containers and any wastes that develop. Only Commercially Certified Operators will apply herbicides for the State, in the appropriate category and after a pre-employment physical.

2. Pesticide common names, application rate, and carrier shall be known.

3. When possible, "Weed Spraying Ahead" signs (similar to "Men Working") should be made and used; and posting should occur if any spraying of parks and open space occurs.

4. Positive placement techniques planned to minimize drift and effects on nontarget areas shall be employed.

5. Optimal method of application (backpack, handgun/tank, computer controlled boomless nozzles with drift retardants) will be used.

6. Special restrictions on the pesticide label with regard to handling, buffer strips, grazing, re-entry, wind, droplet size, etc. shall be followed.

7. Monitoring plans (water, efficacy, nontarget effects, target effects, etc.) are required.

    a. Application operations will typically be suspended when any of the following conditions exist on the treatment area:

        - Wind velocity exceeds 5 miles per hour (8.1 km/h) for the application of liquids or as specified on the label (whichever is less) and will be measured hourly by a hand held meter (to be calibrated monthly). Remote areas may be sprayed with winds up to 10 mph

(16.2 km/h) when drift retardants are used and it is not prohibited on the herbicide label. A buffer zone of 500 feet (152.4 m) will be maintained between such treatments and all subdivisions;

- Snow or ice covers the target foliage;
- Precipitation is occurring or is imminent;
- Fog significantly reduces visibility and indicates a temperature inversion exists;
- Air turbulence (for example, thermal updrafts) is sufficient to affect the normal chemical distribution pattern.
- When the temperature exceeds 90° F; any use of dicamba and/or 2,4-D ester products will stop when the predicted temperature exceeds 85° F for any of the following three days.

b. Equipment will be designed to deliver a median droplet diameter of 200 to 800 microns. This droplet size is large enough to avoid excessive drift while providing adequate coverage of target vegetation. Drift control agents will be used in boomless sprayers.

c. Individuals involved in the herbicide handling or application will be instructed on the safety plan and spill procedures, including the use of the appropriate protective clothing as prescribed on the herbicide label and The Standard Pesticide User's Guide by Bert L. Bohmont, CSU, and containing any spill to the smallest possible area, by using the spill response kit that will be purchased before any applications are done. A cellular phone or other portable communication device will be available in the vehicle to be used in an emergency.

d. Preventive equipment maintenance will include a visual inspection of all hoses and fittings after equipment washdown at each day's end and immediate repair of any problems. Periodic calibration and replacement of any nozzles that show more than 5% variance from the average will occur.

Other general mitigation measures that pertain to treatment methods and alternatives described herein are as follows:

1. Whenever possible, minimum practical application rates will be used that will still meet the needs to effectively controlling or eliminating target species.

2. A preventative maintenance program will be incorporated as part of each project treatment proposal that will help guard against reencroachment of undesirable plant species.

3. Protective buffer zones will be provided along riparian habitats not designed to be treated and along streams, rivers, lakes, wetlands, and xeroriparian areas along dry water courses.

4. The selected herbicides must have a minimum toxicity to the significantly affected fish and wildlife species in the potentially affected treatment area, while maintaining adequate toxicity to the target weed species. When significant impacts to an aquatic system are likely, the following mitigation is recommended:

   - Emphasize other methods of treatment near streams, especially important fisheries.

   - Reduce frequency and rates of application of herbicides by timing application to the most vulnerable phenological events of the target plant species.

   - Establish contingencies through the Safety Plan for immediate reaction and mitigation in the case of accidental spills, unplanned drift, or other serious environmental accidents impacting important streams, water bodies, and humans.

   - Minimize use of chemicals that might have adverse impacts on aquatic habitats.

   - Avoid application time periods when fish are in life stages most sensitive to herbicide impacts (egg, larvae, and smolt) in waters adjacent to the application areas.

5. Prior to herbicide applications, any managed apiaries (honey bee colonies) in the vicinity will be notified in advance to allow time for removal or other protection of the hives.

6. Precautions will be taken to assure that equipment used for storage, transport, and mixing or application will not leak into water or soil creating a contamination hazard.

7. Monitoring of mitigation effectiveness will be conducted.

8. Areas with high risk for ground water contamination should not receive herbicide treatments. All areas considered for herbicide application would be evaluated in terms of the SCS's WATPEST: Soil and Pesticide Interaction Rating Program (computer index that estimates the potential vulnerability to groundwater contamination). Care should be taken to make sure the WATPEST system is applied properly at the site-treatment level. (In all cases where the soil permeability is 6.0 inches or greater per hour, picloram and dicamba would be prohibited.)

If it is determined that high risk areas require herbicide treatment, those areas should be further evaluated to determine the conditions that could allow herbicide application without loss of the herbicide from the root zone. High risk aquifer recharge zones would generally not be considered for herbicide treatment.

Project plans would include the use of applicable best management practices (BMP's) where they exist.

9. When application and timing of herbicide spraying could cause a hazard for human consumption of wild game taken by sport hunters, the spray area should be adequately posted to warn hunters of the potential hazard.

10. Sprayer operators shall know the Spill Incident Response Plan.

11. Standards and guidelines as prescribed in The Standard Pesticide User's Guide: Pesticide Transportation. Storage. Decontamination and Disposal, Chapter 14 will be met. This defines standards for storage facilities posting and handling, accountability, and transportation. It covers spill prevention, planning, cleanup, and container disposal requirements.

Additional data

1. All available sources of information may be used in the ongoing evaluation of chemicals to be used in the State's program.

2. Proposed herbicides to be used in the State program should use the same health and safety standards of review as those currently adopted.

3. Herbicides which have inerts in the EPA's Priority Pollutants List 1 and 2 will not be considered for use by the State.

Zoning

Agricultural versus residential zoning will be utilized as a tool for establishing "no spray" or "limited spray" areas.

1. Areas zoned "Rural Residential" will require no objection from the immediately adjacent owners before any state herbicide treatments occur.

2. Spraying can be performed by the State on state land adjacent to land zoned as "Residential" if a buffer zone is maintained. The recommended buffer width will vary with the herbicide being applied.

In addition, "No Spray" areas should be established for protected areas such as wetlands and threatened and endangered plants. A signing method could be used to delineate the protected areas.

PROJECT DESIGN FEATURES

Minimum Width Buffer Strips

If herbicides are proposed for use, buffer strips will be provided adjacent to dwellings, domestic water sources, wetlands, streams, lakes, and ponds. The width of the buffer zone should be determined by the applicator based on the conditions present and the herbicide(s) used. The following can be used as guidelines. A minimum buffer strip of about 20 feet (6.1 m) for vehicle application and 5 feet (1.5 m) for hand application will be provided. Any deviations must be according to the label for the herbicide. Herbicides will be wiped on individual plants within 10 feet (3 m) of water where application is critical. Agricultural land buffers will be about 5 feet (1.5 m) for vehicle and 0 feet for hand applications.

Recreation Sites

Sites proposed for vegetation treatment with herbicides will be treated prior to or after maximum recreation use occurs (with the appropriate reentry restrictions being posted). Treatment sites, with potential for public use, will be posted with large signs to notify the public of any herbicide used and the date and time.

Wildlife

If herbicides are proposed, those with minimum toxicity to fish and wildlife will be used. Protective buffer zones will be provided along streams, wetlands, rivers, and lakes and riparian and xeroriparian areas along dry water courses. Treatment periods will avoid bird nesting season and other critical seasons when loss of cover or disturbance by equipment would be detrimental to wildlife.

Herbicide Application Requirements

All application contracts will contain stipulations to reduce the possibility for herbicide drift and spills. All personnel involved in pesticide application must be trained and licensed as Colorado Certified Operators. Protective clothing and equipment, as specified on EPA-approved labels and 771e Standard Pesticide User's Guide will be worn by workers directly involved in herbicide applications and by employees using hazardous tools/equipment.

Soil Protection

Mechanical treatment such as mowing shall be conducted so far as practical on the contour to reduce the chance of soil erosion. Tractor operations will be limited to periods of low soil moisture to reduce the chance of soil compaction.

Monitoring and Evaluation

Additional procedures have been identified in this manual based upon the analysis present in the implementation plan adjustments. Manual and mechanical treatments will be monitored at regular intervals to determine the quality and quantity of completed work. Chemical treatments will be

monitored for compliance with proper application technique and safety procedures as described by the Colorado Department of Agriculture. Effectiveness of mitigating measures identified in project-specific environmental documents will be monitored through periodic inspections. Air and water quality will be monitored where appropriate and funds permit.

Post-treatment surveys and evaluations will be conducted to evaluate the effectiveness of the treatment used. Information gained will be used to improve future project design. The State shall work with the Colorado State University Cooperative Extension Service and other organizations to monitor off target surface movement of state-applied herbicides.

Water quality testing (ground and surface) and soil analyses will be done as funds permit:

1. Use groundwater testing to establish baselines before any spraying is done. If an area is already contaminated, no additional herbicide application should be performed.

2. Conduct surface water testing to establish baseline data so reasonable comparisons can be made. It is strongly recommended that the urban and suburban areas be included in this testing.

3. Test soils for herbicide residues. Any time persistence of herbicides in any form is found, it becomes a significant consideration and periodic testing may be necessary.

A three year evaluation period will be established with target dates set to allow re-evaluation at the end of this period. For controls that may take longer than three years, status reports will be provided.

Interrelationships

The State will coordinate its weed and undesirable plant treatment activities with actions of adjacent State agencies, as well as federal, county and local agencies responsible for resource management and with adjacent landowners and managers.

Agencies with regulatory enforcement responsibilities are hereby recognized and their guidance will be followed regarding chemical treatment involving herbicide application controls, such as the Environmental Protection Agency, and the Colorado Department of Agriculture.

Relationship to Other Management Plans

It is hoped that this manual might be a management tool for all counties and residents in the management of weeds prescribed under the IWM program. Those levels and areas identified in this manual form the basis for selection of annual project plans for consideration based on funding and need from one year to the next.

IX. TREES AND BRUSH

The Trees and Brush section provides specific guidelines on the control, removal, and disposal of trees and brush from the right-of-way. Proper removal and disposal of brush and woody plants must be performed on-site in full view of the roadway and must leave the worked area in an acceptable and orderly appearance. For information on the protection of trees during construction see CDOT's Construction Manual or "Tree Preservation and Protection," *Virginia Erosion and Sediment Control Handbook.*

Trees are a desirable element of roadside vegetation. Mature trees located in the right-of-way are there to be enjoyed by the motoring public and wildlife. Dead trees provide habitat for many species and should remain undisturbed if located deep into wide roadsides or medians.

The following are general guidelines to be followed concerning trees and brush in the right-of-way:

1. No trees should be planted or permitted to grow in the highway clear zone.

2. Trees planted on the south and west sides of the roadside need to be controlled if they interfere with winter pavement ice control operations.

3. Dead trees should be removed for highway safety when they obstruct the clear zone or become a hazard should they fall.

4. It is desirable to plant native trees that are indigenous to the area. Native trees should be designed into the roadside and thus can remain for all to enjoy. Nuisance trees or trees not accepted to the area may be removed.

TREE AND BRUSH CONTROL

Tree Control

Trimming and pruning of roadside trees shall be done to promote highway safety, improve roadside appearance, open scenic vistas, provide reasonable vertical clearance and allow the development of other desirable trees. Promoting highway safety involves improving vision at curves and intersections, providing adequate vision in advance of traffic signals and signs and preventing damage caused by breaking limbs. Trimming for safety reasons shall be done when the need for such trimming is apparent, while trimming done to improve appearance or open vistas shall be done only when time allows. Opened vistas shall provide adequate visibility at permissible speeds.

Tree Pruning

Tree trimming and pruning shall be done according to accepted methods and shall be adequately supervised by the district to insure neatness and completion. When pruning for safety or clearance around utility lines, consider the rate of tree growth in determining the amount to be removed from a tree. A slow growing tree will require less clearance than a fast growing tree. Adequate clearance should be maintained, not excessive clearance.

In removing a limb, the cut should be made at a fork where the remaining branch will be at least one third the diameter of the one removed. When removing a limb of two inches (5 cm) or more in diameter, the following procedure should be employed to ensure that bark is not stripped from the remaining branch:

Step 1. Undercut ⅓ of the way through the limb, 8 to 12 inches (20 to 31 cm) from the main stem.

Step 2. Remove limb 4 to 6 inches (10 to 15 cm) out from the first cut.

Step 3. Remove stub with an even cut so that a trace (called a "collar") still protrudes (about ½ inch).

Step 4. Paint the cut with an approved tree dressing or paint.

Roadside Maintenance Clear Zones

Roadside maintenance clear zones shall provide a barrier-free area measured from the pavement edge to enhance the sight of drivers, maintain roadside aesthetics and open the roadway to sunlight in the winter. In general, the clear zone is thirty feet from the edge of pavement, except in National Forest and National Park mountain areas.

In clear zones (Zone 1) make sure that:

1. All trees within the clear zone and vision triangles are cleared;

2. All young trees growing in fence lines, around culverts, near or under bridges and in other undesirable locations are removed (may require a permit);

3. All brush and tree stubble are treated with an approved stubble or basil herbicide (check first with Regional Environmental Manager);

4. All regrowth is treated with an approved foliar herbicide;

5. All limbs, debris and firewood are disposed of properly;

6. All stumps four inches (10 cm) in diameter or larger are ground down to a minimum of four inches above the ground;

7. All brush is cut low enough to allow for mowing (in wetlands this will require a 404 permit and possibly an SB40 permit);

8. All brush that causes vision problems or invades ditches is cut down; and

9. Work involving willows, alders, cottonwoods, etc. may require a permit.

In addition to the above requirements, the following items should be considered:

1. Do not cut beyond the clear zone;

2. Do not limb-up trees, except to remove dead or broken branches;

3. Do not cut mature trees (over eight inches (20 cm) in diameter), trees in dooryards, trees that are memorials, trees that have sentimental value or specimen trees without approval of the maintenance office;

4. Do not cut trees or brush to the clear zone when the back slope is steeper than 2:1. Instead, cut up the slope a short distance;

5. Do not cut dead trees beyond the clear zone unless they could fall onto the roadway;

6. Do not cut to the clear zone in fill sections where there is a guardrail. Instead, cut 10 to 15 feet (3 to 4.6 m) beyond the beam guard; and

7. Do not clear to the construction limits or right-of-way line if they are beyond the clear zone.

8. Do not cut trees are shrubs in wetland or riparian areas without contacting the Regional Environmental Manager.

Some exceptions to the above recommendations are as follows:

1. In sensitive areas, the entire clear zone does not need to be cleared. The policy for such areas should be approved by the maintenance office;

2. Naturally growing trees which grow after placement of an outdoor advertising sign can be cut beyond the clear zone to make the sign visible;

3. If more light is needed for winter maintenance, cutting can be extended up to 15 feet (4.6 m) beyond the clear zone on the south and west side of a roadway if it is on a CDOT right-of-way and is not in a sensitive area (e.g. near homes); and

4. The cut edge (the line of vegetation created by the cutting operation) should not be perfectly straight. Transitions between clear zones should be gentle and flowing.

TREE AND BRUSH REMOVAL

Tree Removal

Dead trees that may fall and affect safety or maintenance operations shall be removed when time and conditions permit, except in wetlands or waters of the U.S.

Living trees shall be removed only if one or more of the following conditions exist:

1. The tree is located in the clear zone;

2. The tree obstructs vision because it is located on the inside of a curve, is at an intersection or at a private entrance;

3. The tree causes continuous shade and an icy spot on an otherwise clear roadway;

4. The tree is at or beyond its maturity or is of a species likely to fall or splinter onto the roadway during storms; and

5. Two or more trees are in close proximity to each other and therefore are impeding satisfactory development. In this case, selective removal of the weaker or less desirable tree may be done.

6. For fire consideration.

Unnecessary and indiscriminate tree removal shall not be permitted, and all removal operations shall be planned and conducted with the public in mind. When trees have particular sentimental value, act as memorials or reside in dooryards, their removal may cause controversy. Such tree removal shall require approval by the maintenance office.

The stumps of removed trees shall be either completely grubbed out or cut down as close to the ground as possible and treated with a vegetation-control chemical. Whenever tree removal may jeopardize utility fixtures, the utility company shall be contacted and asked to supply personnel to supervise and insure safe removal.

Trees will not be cut into fireplace lengths on state time or used by CDOT employees. All trees cut should be hauled to a proper disposal site.

Brush Removal

Growths of brush that create traffic hazards, detract from roadside appearance or interfere with other maintenance activities, shall be cut down as time allows, even during winter months.

The following areas should be kept free of all brush and high-growing vegetation.

1. Any point where brush would or does restrict vision, such as at curves, at intersections or private entrances, or near highway guide signs;

2. In stream channels or culvert discharge ditches where brush tends to block the free flow of water (may require a 404 permit);

3. Any area on a right-of-way where brush causes drifting of existing snow onto the roadway or to a location where drainage may be blocked;

4. Any area within the clear zone (Zone 1) where brush makes mowing difficult;

5. Beneath bridges where brush can be a potential fire hazard; and

6. Any area where selective cutting enhances roadside appearance. Removal may either rid the area of undesirable species of brush or make native species more viewable.

7. Brush removal in wetland or other aquatic environments may require a 404 and/or SB40 permit.

Stems of brush cut for any of the above reasons shall be treated with an approved chemical to prevent regrowth. The chemical shall be applied in such a way as to insure complete saturation of any stems cut and removed. In wetlands or other aquatic environments only approved herbicide should be used if absolutely necessary.

Diseased Trees and Brush

Any tree or brush on the right-of-way and infected with a disease, such as Dutch elm disease or Oak Wilt, shall be removed and disposed of by means of chipping or burying before the beginning of the following April. The stump shall be completely grubbed out and disposed of, ground out or debarked to a point six inches (15 cm) below the ground surface.

TREE AND BRUSH DISPOSAL

Debris from brush and tree trimming operations that is smaller than four inches in diameter shall be disposed of promptly. Chipping, hauling away and natural decomposition in place are the preferred methods of disposal. All debris in wetlands and other aquatic environments must be removed.

1. Chipping shall be either uniformly spread over a large area so that no pile will be created, or, used for mulch in landscape plantings.

2. Hauling to a disposal site shall be acceptable if the cost is reasonable.

3. Natural vegetation disposal shall be allowed in wooded areas as follows:

    - Twigs, branches and trunks too large or small to be convenient firewood or of poor quality or small quantity may be left in the wooded areas;

- A natural disposal pile shall be trimmed and laid flush on the ground so not visible from the roadway; and

- Unsuitable materials remaining visible from the roadway shall be removed from the right-of-way and disposed of properly.

X. WETLANDS, ENDANGERED PLANTS, AND WILDLIFE HABITATS

The following section describes how vegetation management techniques affect wetlands, endangered plants, and wildlife habitats.

Habitat degradation and loss is now the most significant problem associated with maintaining healthy populations of wildlife and plant resources. Over one-half of the wetland habitats in the continental United States have disappeared. Remaining habitats have suffered too. Human development has fragmented them; poor land management practices have modified them; the introduction of exotic plants and animals has displaced native species. As native wildlife and plant habitats continue to decline, those that do remain gain importance. Remaining habitats are important both to the resources dependent on them and to the public. Increasingly, the public views natural resources as part of our heritage. Thus roadsides, through their permanence and statewide distribution, have gained importance as plant and wildlife habitats.

WETLANDS

The term "wetland" specifies 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, assorted vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, fens, peatlands, mangrove forests, coastal saltmarshes and other similar areas. Wetlands can serve as nursery and spawning grounds for fish and home for many animals. Wetlands temporarily store flood water and slowly release it downstream, thereby reducing flood flows and peaks. Their soils and vegetation can help remove impurities from water, reduce sediment and nutrient loads, and bind soil to help prevent erosion. The position of wetlands between uplands and water bodies greatly facilitates their flood protection and water quality maintenance functions.

Departments of Transportation across the nation face the problem of trying to avoid destruction or alteration of wetlands while construction and maintenance of highways and bridges occurs. Before an organization can perform any construction or maintenance activity which could threaten to alter or destroy a wetland, it must first obtain a permit from the United States Corp of Engineers, Department of the Army. The permit application must be reviewed and approved by a number of governmental agencies, including but not limited to: (1) U.S. Environmental Protection Agency; (2) U.S. Fish and Wildlife Service (Department of the Interior); and (3) National Marine Fisheries Service of the National Oceanic and Atmospheric Administration.

STRIVE FOR DIVERSITY

Any vegetated area provides food and cover for at least some wildlife species. If plant diversity is restricted, however, wildlife diversity will also be limited. Different animals require different habitats. Plant diversity is essential to maintaining an abundant and varied wildlife population.

Growth structure is another important factor affecting the quality of wildlife habitats. "Growth structure" simply refers to the height and coverage of the vegetative canopy. Promoting a diverse vegetative growth structure will also encourage wildlife diversity.

The following sections describe what effect different aspects of roadside vegetation management can have on wildlife habitats.

Mowing Wisely

In intensive agricultural areas, monocultural row crops dominate. In these areas, the only suitable nesting habitat for upland birds is within highway rights-of-way. The timing and frequency of mowing schedules in these areas dramatically affects nesting success.

Roadsides are especially important to wildlife in rangeland areas subjected to continuous livestock grazing. Since boundary fences normally keep domestic livestock off the right-of-way, the roadsides in these areas usually provide a higher diversity of grasses and forbs than the heavily-grazed adjacent lands.

The goal should be to establish non-mow areas and adjust mowing schedules to accommodate wildlife whenever possible.

Using Trees and Shrubs

Incorporating woody shrubs and trees into roadside landscapes will provide additional sources of food, escape cover, nesting cover, and roosting areas for wildlife.

Nurturing Seeds

In many areas, land use practices have, over the years, inhibited the growth of specific native plants. One reason this happens is because plants are not allowed to die off naturally and provide seed for the next generation. This process is particularly important in maintaining grass and forb species that depend on seed dispersal. Roadside vegetation management practices should encourage seed production and proper dispersal. This can be done by: (1) properly selecting native plants; and (2) adjusting mowing schedules to allow for seed production and dispersal.

Encourage Wildflowers

Not only are wildflowers popular with the traveling public but they are beneficial to wildlife. Wildflowers and other forbs serve as important food sources to deer. The seeds these plants produce provide food for many other wildlife species, including birds and small mammals. The plants also participate in an intricate food web, supporting many insects and other invertebrates on which other wild animals depend.

Roadsides typically sustain a greater density and variety of wildflowers than adjacent pastures and fields. Therefore, encouraging roadside wildflowers strengthens wildlife diversity.

WILDLIFE DENSITY AND SAFETY

The question "will more wildlife along roadsides create additional traffic hazards?" is frequently asked. Some people may believe that more wildlife along roadsides will create additional traffic hazards and accidents, but this may not be completely accurate.

The main factors affecting wildlife-vehicle collision rates are the types and conditions of habitats of adjacent lands and associated wildlife population densities on those lands. Deer prefer particular travel corridors. Their movement patterns are based on the available cover and the juxtaposition of favored habitats. A greater frequency of road crossings will occur where a highway intersects these preferred habitats. Other species of wildlife that typically use established corridors include raccoon, skunks, opossums, squirrels, coyotes, bobcats, and some songbirds. These animals are likewise vulnerable to road kills. Road crossings at creek and river drainages are good examples of this relationship. A greater frequency of auto collisions would occur in this situation regardless of the roadside vegetation management practices. Consider placing signs to warn motorists at known or expected wildlife-vehicle collision locations.

XI. REFERENCES

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Tarrer, Arthur Ray, "Impacts of Environmental, Health and Safety Regulations on Highway Maintenance," NCHRP 14-9 (5), prepared for the national cooperative Highway Research Program, Transportation Research Board, National Research Council, May 1993.

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Herbicide Operations Manual, developed by the Landscape Section of the Division of Maintenance and Operations, Texas Department of Transportation, 1992.

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Maintenance Manual: Policies, Directives, and Guidelines, Chapters 70, Roadside Maintenance and 74, Vegetation Management, Wisconsin Department of Transportation, Division of Highway Maintenance, January 1994.

Managing Competing and Unwanted Vegetation: Final Environmental Impact Statement, Pacific Northwest Region, U.S. Department of Agriculture, Forest Service, November 1988.

A Practical Guide to the Establishment of Vegetative Cover on Highway Rights-of-Way, Texas Department of Transportation, November 1993.

Roadside Mowing Manual, Bureau of Maintenance, Ohio Department of Transportation, 1983.

Roadside Vegetation Management: Draft Environmental Impact Statement, Washington State Department of Transportation, February 1993.

Roadside Vegetation Management Handbook, New Mexico State Highway and Transportation Department, March 1992.

Roadside Vegetation Management: A Volume of the Infrastructure Maintenance Manual, Texas Department of Transportation, November 1993.

XII. ADDITIONAL RELEVANT DOCUMENTS

CDOT "Adopt-A-Highway Program".

CDOT "Erosion Control and Stormwater Quality Guide"

CDOT "Seeding Manual".

"Tree Preservation and Protection," *Virginia Erosion and Sediment Control Handbook*, Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, 3rd Edition, 1992.

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Bohmont, Bert L. *Standard Pesticide User's Guide.*

Tabler, Ron. "Blowing and Drifting Snow Control Measures," SHRP Research Project Report, 1993.

Herbicide Operations Manual, developed by the Landscape Section of the Division of Maintenance and Operations, Texas Department of Transportation, 1992.

APPENDICES

APPENDIX A. FEDERAL AND STATE CONTACTS

The following is a list of some of the agencies and services that are available to answer questions and provide assistance with technical questions.

STATE AGENCIES

Dave Fraser (303) 757 9536
TITLE
Colorado Department of Transportation
Empire Park, Building B
1325 Colorado Boulevard, Suite 707
Denver, CO 80222

Mike Banovich (303) 757 9174
Staff Design Landscape Architect
CDOT
4201 East Arkansas Avenue
Denver, CO 80222

Kris Meiring (303) 757 9790
Office of Environmental Services
CDOT

Colorado Transportation Institute (303) 248 7231
222 South 6th Street, Room 317
Grand Junction, Colorado 81501
Bob Barrett

Colorado Department of Public Health and the Environment (303) 692 3300
Waste Management Section
4300 Cherry Creek Drive South
Denver, CO 80222-1530

FEDERAL AGENCIES

EPA Hotline (202) 260 4977

EPA National Headquarters (202) 260 4700
Office of Solid Waste and Emergency Response
Washington, DC 20460

EPA Region VIII (303) 293 1603
Waste Management Division (8HWM-ON)
One Denver Place
999 18th Street, Suite 1300
Denver, CO 80202-2413 (Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming)

National Park Service (202) 208 3163
Environmental Quality Division
Room 1210 - MIB
1849 C Street NW
Washington, DC 20013

National Army Corps of Engineers (202) 272 0660
Regulatory Branch
Room 6225
20 Massachusetts Avenue, NW
Washington, DC 20314-1000

Fish and Wildlife Service (202) 208 5634
Department of Public Affairs
1849 C Street NW
Washington, DC 20240

National Oceanic and Atmospheric Administration (202) 606 4380
Public Affairs Office
Room 5805
14th 8 Constitution Avenue, NW
Washington, DC 20230

Department of Agriculture (202) 720 2791
Publications Office
Room 507A
Washington, DC 20250

Office of Hazardous Materials Transportation (202) 366 0656
400 7th Street SW
Washington, DC 20240

Bureau of Land Management (202) 208 5717
Public Affairs Division
1849 C Street NW
Washington, DC 20240

Occupational Safety and Health Administration (202) 219 8148
Office of Information and Consumer Affairs
Department of Labor/OSHA
200 Constitution Avenue, NW
Room N - 3647
Washington, DC 20210

APPENDIX B. PHENOLOGY, OCCURRENCE AND CONTROL OF STATE-DESIGNATED WEEDS

The following section includes physical descriptions of the four state-designated weeds and recommended control methods for each weed.

ADD A PICTURE OF EACH PLANT.

LEAFY SPURGE

Leafy Spurge [*Euphorbia esula*] (Noxious; Spurge Family) is a creeping, herbaceous perennial weed capable of reproducing from seed and vegetative root buds. It was introduced from Europe during the 19th century as a seed contaminate of small grains and grass seed. It is an economically important weed that can reduce rangeland cattle carrying capacity by 50 to 75%. About half of this loss is due to decreased grass production. Additionally, cattle avoid grazing in dense leafy spurge stands therefore, heavily infested areas essentially are a 100% loss to producers. The U.S. cattle industry loses millions of dollars annually to leafy spurge infestations. When established, it crowds out practically all other vegetation.

Leafy spurge infests over 2.5 million acres in North America. Over 1 million acres in North Dakota and Montana are infested with leafy spurge and about 50,000 acres in Wyoming. There are approximately 30,000 infested acres in Colorado. Leafy spurge occupies a broad ecological range. Although it frequently becomes established in moist areas, such as along waterways in eastern Colorado where it is spreading rapidly, it also is well-adapted to dry, upland sites and shallow, rocky soils. It grows in pastures, rangeland, and waste areas throughout Colorado at elevations from 5,000 to 6,000 feet.

Leafy spurge is an erect plant and grows 1 to 3 feet tall. Leaves alternate on shoots, bluishgreen, with smooth margins. They are narrow, 0.25 to 0.5 inches wide, and 1 to 4 inches long. Flowers are borne in an umbel and surrounded by heart-shaped, showy yellow-green bracts. Flowers occur in numerous clusters toward the top of the plant. The seeds are found in a visibly divided three-celled capsule. Seeds are round to oblong, about 1/12 inch long, gray or mottled brown with a dark line on one side.

Leafy spurge contains a white milky latex in all plant parts. Latex is a key identifying characteristic and helps to distinguish leafy spurge from other weeds, such as yellow toadflax, particularly when plants are in a vegetative growth stage.

Leafy spurge has an extensive root system that is most abundant in the top foot of soil but may grow 15 feet deep. Consequently, it seldom experiences a deficiency of water. Roots contain substantial nutrient reserves that allows the weed to recover from stress, including most control efforts. Numerous vegetative buds are found all along roots and these cause new shoots to contribute to its persistence and spread.

Leafy spurge shoots start early each spring from crown tissue just below the soil surface and from adventitious buds along its root system. Leafy spurge is one of the first plants to emerge each spring and consequently uses moisture and nutrients that otherwise would be available for

desirable vegetation. In Colorado, vegetative plant emergence occurs from late February through May depending on location. Leafy spurge displays early rapid growth that makes it extremely competitive with desirable vegetation.

Leafy spurge is one of the first plants to emerge each Spring. In Colorado, emergence occurs between late February through May depending on location. Flowering generally occurs in April and May. Bracts emerge about 2 weeks before flowers and give leafy spurge the appearance of flowering. Optimum herbicide application requires recognition of true flower emergence. If moisture conditions are good, flowering can continue into the summer and fall. The latter can occur until shoots are killed by freezing temperatures. Seed development is complete 20 to 30 days after emergence of female flowers. Each flowering shoot produces 10 to 50 three-lobed capsules and usually contain three seeds per capsule. Seeds are forcibly expelled up to 15 feet from the parent plant when capsules dry. An average of 140 seeds per flowering shoot are produced and seeds are viable up to 8 years in soil. Seed production can average 2400 seeds per square yard. Water, birds, animals, and human activities aid seed dispersal. Leafy spurge seeds readily float and waterways, particularly in eastern Colorado, are good sources for new infestations.

Peak seed germination generally occurs in May although germination may occur throughout the growing season. Seedlings quickly develop a perennial habit, i.e., the ability to reproduce vegetatively, and perennial leafy spurge is much more difficult to control than seedlings. Seedlings develop vegetative buds within 10 to 12 days after emergence.

This weed can regrow from roots only one week after germination. Farm and construction equipment should be cleaned before moving from an infested site. Eradicate small patches before they become a major problem.

Cultural Control

Seeding and maintaining selected perennial grasses has been found to be an effective tool. Early emerging grasses, such as smooth brome and crested wheat grass, that utilize early season moisture, have reduced spurge density and limited the spread and establishment of new infestations. Sequential glyphosate (e.g. Roundup) applications followed by a seeding of Luna pubescent wheatgrass, Ephraim crested wheatgrass, intermediate wheatgrass, Sherman big bluegrass, or Bozoisky Russian wild rye, has shown to be effective in reducing an infestation of spurge in Wyoming. Proper grazing management is always a desirable cultural tool.

Mechanical Control

Mechanical control of spurge is difficult, at best. However, multiple stresses applied to plants are very effective. Frequent mowings through summer reduces herbicide application amounts needed in the fall. Mowing spurge at regular intervals 4 to 6 times per spring/summer is an effective stress treatment that will reduce root food reserves and prevent seed set. Mow as plants regrow and before flowering stage. Spurge's milky sap has been known to gum up mowers.

Cultivation can be done at two to four-week intervals, but is costly and can bare soil to erosive factors. Research results are not available which indicate whether stand reduction or eradication can occur from the sole use of mechanical controls.

Biological Control

Research is being performed using sheep to graze spurge as a stress treatment. Thus far both sheep and goats have been found to be effective grazers of spurge. The milky sap of this weed is injurious to cattle mouths. Grazing sheep can commence after spring regrowth reaches two to six inches tall, but before the flowering bract stage. Goats can graze spurge at any time. Grazing can proceed to approximately mid-August. Do not overgraze. If animals are turned into a site after spurge has set seed, quarantine animals in a corral for seven days before releasing them into a non-infested pasture. Sheep may require a period of two weeks before they readily eat spurge.

Several insect species have been released by the USDA/APHIS which affect spurge. Of these flea beetles (Apthona spp.) have been found to be very effective after two to three years. Three species have been found to be most effective. Each requires dry, sunny sites.

1. Hyles euphorbiae: A leaf feeding caterpillar more commonly known as the leafy spurge hawkmoth. Disease seems to be a major deterrent in rearing this insect. Birds tend to eat them, making them a bad investment.

2. Apthona nigriscutis: A flea beetle; the larvae burrows into the roots of spurge plants; adults feed on the leaves of spurge.

3. Apthona flava: Similar to above.

4. Bayeria capitigena: A midge that causes tumorlike galls to form when its larvae eat the growing tips of spurge; The midge kills the tips thus stopping the plants growth as well as seed production.

Integrated Management Options By Site

Range, Pasture Parks and Riparian Sites

Option 1. Biological and Herbicide Control

Graze with sheep or goats from April through late August, followed by a herbicide treatment in late September or early October.

Option 2. Mechanical and Herbicide Control

Mow at least two times per spring/summer. Cease mowing in late August. Follow with a herbicide treatment during late September or early October.

Option 3. Biological or Mechanical Control only

Use of sheep or goats, blading or mowing (or shoveling, hoeing, chopping, etc.) will be used all growing season with the expressed purpose of keeping spurge from setting seed. Use of these methods may still allow the spread of rhizomes.

Option 4. Herbicide Control Only

Herbicides will be used in the late spring during the true flower stage. This stage is impossible to determine without close inspection of the opened, yellowish-green flower within the yellowish bracts. If possible a treatment will also be made in early fall. Only herbicides labelled for the site will be used.

Irrigation Ditches

Option 1. Mechanical and Herbicide Control

Hand chopping, hoeing, weed-eating etc. will be used 3 to 6 times per growing season to prevent seed set and stress the plants. Apply labelled herbicides in late September/early October.

Option 2. Herbicide Control Only

Labelled herbicides will be used in late spring during the true flowering stage, and in early fall after a light freeze.

Road Rights-of-way and Other Non-Crop Areas

Option 1. Mechanical and Herbicide Control

These sites will be mowed, or otherwise mechanically controlled, two or more times per growing season. A herbicide application will be made to visible regrowth in the fall.

Option 2. Herbicide Control Only

On sites that cannot be mowed, undesirable plants will be controlled by labelled herbicides. Treatments will be made in late spring and/or early fall, just after a light frost.

RUSSIAN KNAPWEED

Russian Knapweed [*Centaurea repens*] (Noxious; Aster Family; Thistle Tribe) is a creeping, herbaceous perennial forb that reproduces from seed and vegetative buds in its root system. Shoots are erect, about 18 to 36 inches tall, and many branched. Lower leaves are two to four inches long and deeply lobed; upper leaves are smaller, generally with smooth margins, but can be slightly lobed. Shoots and leaves are covered with dense gray hairs. The cone-shaped flowering heads are solitary and occur on shoot tips; they generally are 1/4 to 1/2 inch in diameter and have smooth papery bracts. The lower color can be pink, lavender, or white. The achenes are chalky-white or gray, oblong, 1/8 inch long, with a bristly, deciduous pappus. Russian knapweed has horizontal roots that have a brown to black, scaly appearance. This assists in easy identification of the plant.

Russian knapweed forms dense, single species stands over time due to allelopathy and competition.

Russian knapweed emerges in early spring. It generally begins bolting in May to June (elevation dependent) and flowers through the summer into fall. Seeds are produced sparingly (approximately 1200 per plant) and are viable for 2 to 3 years in soil. The weed expends most of its reproductive energy by vegetative propagation. Roots expand rapidly covering up to 12 square yards in diameter in two growing seasons. They may penetrate to a depth of more than 2 feet in good soils.

Russian knapweed is native to the southern Ukraine, southeast Russia, Iran, Kazakhstan, and Mongolia. It occurs in these regions on clayey, sandy or rocky steppes and sunny meadows, on saline soils, or clayey, rocky or sandy shores of lakes and rivers, on rocky and clayey slopes of hills and bottomlands. It is a weed of cultivated land, dry pastures, and waste places in its native land. Russian knapweed occurs in most western states. In Washington, it is common on heavier, often saline soils of bottomlands and occurs in pastures, hayfields, grainfields and irrigation ditches. In Colorado, Russian knapweed apparently is not restricted to any particular soil type and occurs in pastures, agronomic crops, roadsides, waste places, and some rangeland. It is distributed throughout Colorado except in the Eastern plains area and is especially prevalent on the Western slope from 4,500 to 7,500 feet. Stands may survive 75 years or longer. Russian knapweed is toxic to horses.

There are an estimated 50,000 acres infested with Russian knapweed in Colorado in at least 27 counties. This is Colorado's lowest acreage noxious weed. It is the most difficult to control knapweed, because of its creeping root system. Clean construction and farm equipment before moving from a noxious weed site. Eradicate any plants found. This weed is allelopathic (it creates its own growth retardant herbicide for competitors).

Seeding and maintaining aggressive grasses such as smooth brome will help in competing with Russian knapweed and slow its spread. However, such grasses typically do not perform well on dry range sites. Proper fertilization, grazing and supplemental irrigation of grasses are always effective cultural control methods.

Due to the allelopathic properties of this weed, supplemental control methods, such as judicious use of herbicides, may be needed to give grasses a chance to compete.

Mechanical Control

Mowing and other mechanical methods can be employed every 14 to 21 days to prevent seed set and to stress the plants. Whether these efforts will reduce root mass and plant stand is unknown.

Biological Control

No effective biological control agents are known currently for this weed. Horses cannot be allowed to graze this knapweed because they will develop a chewing disease.

Integrated Management Options By Site

Range and Pasture lands, Road-Right-of-Ways, and Non-Crop Areas

Option 1. Mechanical and Herbicide Control

Mowing or other mechanical efforts are performed throughout the growing season, with the first and successive efforts done at the bud stage. Apply herbicide in early fall, after a light freeze.

Option 2. Cultural and Herbicide Control

To an existing infestation, apply a short-residual herbicide, such as glyphosate or 2,4-D. Follow-up by successfully seeding a competitive grass. Fertilize adequately and in a timely manner to stimulate grass growth. Post apply a labelled herbicide to any knapweed that is outcompeting grass.

Option 3. Herbicide Control Only

Apply labelled herbicides to Russian knapweed during the bud stage, bloom to post-bloom, and/or in early fall, depending on type of herbicide.

DIFFUSE KNAPWEED

Diffuse knapweed [*Centaurea diffusa*] (Noxious; Aster Family; Thistle Tribe) is a biennial or short-lived perennial forb that reproduces solely from seed. The plant generally develops a single shoot, 1 to 2 feet tall, that is highly branched toward the top. Rosette and lower shoot leaves are finely divided; leaves become smaller toward the top of the shoot and have smooth margins. Numerous flowering heads are solitary, occur on shoot tips, and are about 0.125 inches in diameter and 0.5 to 0.67 inches long. Flower color is usually white to rose, sometimes purple. Involucre bracts are divided like teeth on a comb, tipped with a definite slender spine that makes it sharp to the touch. Sometimes the bracts are dark-tipped, or "spotted", like spotted knapweed but the long terminal spine differentiates diffuse from spotted knapweed. Upon drying, the bracts become tough, rendering them injurious to the touch.

Diffuse knapweed seeds germinate in spring or fall. Seedlings develop into a rosette and survive the first growing season as such. Rosettes resume growth early in their second spring, bolt, flower, set seed and die. Bolting generally occurs in May to June and flowering in June and July.

Diffuse knapweed is native to waste places and seashores from southern Europe to the northcentral Ukaine. It generally is found on dry, light, porous soils in Europe. Diffuse knapweed occupies similar areas in the U.S. In Washington, it thrives on well-drained, lighttextured soils. It apparently occupies similar sites in Colorado, but infestations have not been accurately mapped. Diffuse knapweed will not tolerate flooding or shade and thrives in the semiarid west (generally in 9 to 16 inch precipitation zones). Environmental disturbance (e.g. overgrazed pastures or rangeland, roadsides, rights-of-way, gravel piles, etc.) enhances its capacity to invade an area.

The worst infestations occur along the Front Range in Larimer, Boulder, Douglas, and El Paso Counties. Severe infestations also occur in Archuleta and La Plata Counties.

It is an easy to control knapweed, because it is a biennial with a tap root system. Cleaning construction and farm equipment before moving from a noxious weed sitewill prevent or reduce further spread. Eradicate any lone plants found with a shovel or by pulling before flowering.

Cultural Control

Cultural control measures for diffuse knapweed are similar to those for Russian knapweed. Although diffuse is not known to be allelopathic, seeding alone in infested sites will not provide adequate control. It produces early spring growth which is difficult to compete against.

Mechanical Control

Mowing (or other mechanical efforts) diffuse knapweed when it is in the bud stage, and again when it flowers, can significantly reduce seed production. Preventing seed-set for a number of years will eventually eliminate an infestation, once the seed source in the soil is depleted. This assumes no seed enters the area from an outside source. This weed has been known to flower at a plant height below mower level.

Biological Control

Two species of picture-winged flies show promise in their ability to reduce the seed production of this weed:

1. Urophora affinis: Picture-winged fly. The insect produces a gall in the seed heads of knapweed, thus inhibiting seed production.

2. Urophora quadrifasciata: Similar to above.

Integrated Management Options by Site

Range and Pasture lands, Riparian and Non-Crop Areas, and Rights-of-Way

Option 1. Cultural and Herbicide Control

A short residual herbicide application will be made in early summer when diffuse knapweed is in the rosette to bolting stages. Another application may be needed in late summer. Selected competitive, perennial grasses will then be seeded in late October or early November.

Option 2. Biological and Herbicide Control

When they become available to the public as effective tools, release of such insects as picture-winged flies should be considered. Introduction of such flies by transporting infested plants to diffuse knapweed sites can also be

done in the fall. Flies from the plants will release themselves in the next spring, and infest new knapweeds.

A herbicide treatment will then be made to weed rosettes in the fall, after the flies have completed their life cycle.

Option 3. Mechanical and Herbicide Control

Mowing (or other mechanical efforts) will be done when this weed is in the bud stage, and again at flowering after regrowth. A herbicide application will then be made to plant regrowth that shows signs of flowering.

Option 4. Mechanical Control Only

Mowing (or other mechanical treatments) will be accomplished throughout the growing season as needed to reduce seed-set.

Option 5. Herbicide Control Only

Herbicide applications will be made to weeds in the rosette stage, during spring or fall. Bolting plants will also receive treatments.

SPOTTED KNAPWEED

Spotted knapweed [*Centaurea maculosa*] (Noxious; Aster Family; Thistle Tribe) is a weed similar in appearance to diffuse knapweed with some notable exceptions. Spotted knapweed is a simple perennial that reproduces from seed (primary means of spread) and forms a new shoot each year from a taproot. The weed can produce one or more shoots that are branched and 1 to 3 feet tall. Rosette leaves can be six inches long, narrowly elliptic in shape, and deeply lobed. Leaves on shoots are smaller and finely divided, similar to diffuse knapweed, and become smaller toward the top of the shoot. Flowering heads are solitary and occur on shoot tips. They are approximately the same size as diffuse knapweed heads. Flower color usually is lavender to purple, rarely cream-colored. Involucre bracts are stiff and black-tipped; the tip and upper bract margin have a soft spinelike fringe and the center spine is shorter than others. This is a key difference between spotted and diffuse knapweeds.

Spotted knapweed seeds germinate in spring or fall. Perennial plants resume growth in early spring and bolt at approximately the same time as diffuse knapweed. Flowering occurs throughout the summer into fall.

Spotted knapweed is native to central Europe where it is found in light, porous, fertile, well-drained, and often calcareous soils in warm areas. It occupies dry meadows, pastureland, stony hills, roadsides, and the sandy or gravelly floodplains of streams and rivers. In the U.S., spotted knapweed thrives on Montana rangeland where soils are light textured, well-drained and receive summer precipitation. Spotted knapweed tolerates dry conditions, similar to diffuse knapweed, but will survive in higher moisture areas as well (thrives in the wetter climatic conditions of the

western Montana mountains). Spotted knapweed infestations in Colorado are often associated with diffuse knapweed.

Spotted knapweed infestations appear to be less severe in Colorado than diffuse knapweed. However, this weed spreads rapidly. Spotted knapweed was first observed in Gallatin County Montana in the 1920's, but now can be found in all Montana counties. Approximately 2 million Montana acres were infested with spotted knapweed in 1983; over 4.7 million acres are infested today.

Cultural, Mechanical and Biological Control

The methods for control of spotted knapweed are similar to those for the other two knapweeds previously addressed.

APPENDIX C. BACKGROUND OF COUNTY DESIGNATED UNDESIRABLE PLANTS[3]

The following section contains descriptions of weeds that are listed in the county Undesirable Plant Management Plans that have been received by Colorado State University, Department of Civil Engineering. A list of each weed and what counties have designated them for management can be found in Appendix E.

JOINTED GOATGRASS [*Triticum cylindricum* or *Aegilops cylindrica*]. (p.28)

Noxious. Grass family. Barley tribe. Jointed goatgrass behaves as a winter annual in Colorado. It probably was introduced to the United States in wheat from Turkey in the late 1800's and is rapidly spreading in grain growing areas. It grows 15 to 30 inches tall in erect stems which branch at the base to give the plant a tufted appearance. The leaf blades are 1/8 to 1/4 inch wide (usually smooth) with small auricles at the base. The ligule is a fringe of hairs. The root system is shallow and fibrous. The most distinguishing characteristic is the 2 to 4 inch cylindrical, balanced spike. The spike has rarely two and up to 10 or more two- to three-flowered (infrequently five) hairless spikelets. Each spikelet is about 1 inch long, and they are tightly arranged alternately each slightly longer than the internode of the rachis. The spikelets most commonly contain two fertile florets and one reduced nonfertile floret. The glumes are several nerved with a keel on one side which extends into a single awn. The lemma slightly exceeds the glumes and has several harsh awns which give the entire head a bearded appearance. At maturity the spike falls intact and the spikelets then separate with a segment of the rachis still attached. The seed is about 3/16 inch long, bearded at one end and resembles a wheat grain. Seed is shed in June and July during and prior to wheat harvest. It is becoming increasingly common in the dryland areas of Eastern Colorado.

WILD PROSO MILLET, broomcorn millet [*Panicum miliaceum*]. (p.40)

Grass family. Panicgrass tribe. Wild proso millet may have been introduced from China. It is an annual which reproduces by seed. The culms grow from 24 to 100 inches or more tall but may be decumbent at the base. The plants can be distinguished from most other weedy annual grasses at any stage of development, by the long spreading hairs on the leaf sheaths. It is similar to *Panicum capillare* (Witchgrass) but grows much larger. The leaf blades are somewhat hairy, usually 12 inches long, less than an inch wide, and rounded at the base. The panicles range from 4 to 18 inches long and are usually nodding and compact but may spread. The numerous panicle branches are ascending, rough to touch, and spikelet bearing toward the ends. Each spikelet is about 2 inches long and consists of two glumes, a sterile floret, and a fertile floret consisting of a caryopsis enclosed by a hard, smooth, shiny lemma and palea. There are prominent light colored nerves on the fertile lemma and palea. Seeds are olive-brown to black in color and may darken with age. They are usually no more than 1/8 inch wide and only slightly longer. Some seeds normally shatter to the ground prior to harvest but they are also harvested with many crops. It is found in irrigated areas in Eastern Colorado.

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[3] All entries copied from: *WEEDS OF COLORADO*, by Robert L. Zimdahl, Cooperative Extension, COLORADO STATE UNIVERSITY, Fort Collins, Colorado, 1983.

JOHNSONGRASS [*Sorghum halepense*]. (p.43)

Noxious. Grass family. Bluestem tribe. This creeping perennial was introduced from Southern Europe and Asia. It reproduces by seeds and stout horizontal rhizomes. It grows erect from 2 to 5 feet tall and resembles sudangrass. The stems are smooth, pithy, stout and bear narrow, smooth, flat leaves 12 to 18 inches long. The flowers and seeds are borne in large, loose, purple panicles. It may be poisonous to livestock due to the presence of hydrocyanic acid as a result of interruption of normal growth by drought or other factors. It grows in cultivated fields and waste places and is becoming a serious weed in southeastern Colorado from 3.500 to 4 200 feet. It will gradually move north.

MEADOW DEATHCAMAS [*Zigadenus venenosus*]. (p.49)

Lily family. This native perennial, hairless herb has mostly basal, grasslike leaves and underground perennial bulbs or rhizomes. The sparingly leafy stems are single, unbranched and produced at the time of flowering. The plants are 8 to 14 inches tall with sheathing, linear leaves surrounding the stem. The leaves are flat, V-creased parallel veined, and never hollow. The inflorescence is a raceme of green-white, yellow, or pink flowers. The underground bulb is onion-like with a dark colored outer coat. The wrinkled, light brown seeds are produced in a capsule. The entire plant is poisonous because it contains an alkaloid, zygacine, which is toxic to all stock, but especially to cattle and sheep. It is found in the western two-thirds of Colorado from 4,500 to 8,000 feet.

HALOGETON [*Halogeton glomeratus*]. (p.62)

Noxious. Goosefoot family. Halogeton is an introduced annual which reproduces by seeds. Its stems are smooth and spread out from the base and then grow erect to form a bushy plant. The stems are sometimes red to purple tinged and grow 1 inch to 1 foot tall, depending on conditions. Large plants can be 3 feet in diameter. The leaves are fleshy, linear cylindrical or wiener-shaped and 1/4 to 1/2 inch long. The blunt end is tipped with a spinelike hair. The flowers are yellow or green, of two kinds, and mostly inconspicuous. The seeds are also of two kinds, and conspicuously winged and frequently so crowded on the stems as to constitute the only visible portion. The spiral embryo is indicative of Halogeton's close relationship to Russian thistle. Large plants may break off and blow as tumbleweeds. It is a prolific seeder through most of the summer. The original infestation was reported from Nevada in 1934. The first Colorado infestation was along railroad spurs near the Utah line where sheep from an infested area were unloaded. It is spreading in spite of control efforts. It contains an oxalate poisonous to sheep and has caused heavy losses where other forage was limited. It grows on saline and desert land but is also an aggressive invader in other types of grazing areas.

KOCHIA fireweed, Mexican fireweed [*Kochia scoparia*]. (p.63)

Goosefoot family. This is a native of Asia introduced from Europe. It is an annual which reproduces by seeds. The stems are erect, round, slender, pale green, much branched and 1 to 6 feet high. The leaves are alternate, lance-shaped or linear and hairy, especially on the margins. The upper leaves are narrow. The flowers are inconspicuous, sessile in the axils of the upper leaves, and form short, dense, bracted spikes. The seeds are about 1/16 inch long, wedge-shaped,

dull brown and slightly ribbed. In autumn the plants may become red in color and later turn brown. It grows in cultivated fields and waste places, statewide up to 8,500 feet.

RUSSIAN THISTLE Russian tumbleweed, tumbling thistle [*Salsola iberica* or *Salsola collina*]. (p.65)

Goosefoot family. Russian thistle was introduced from Russia. It is an annual which reproduces by seeds. S. iberica is a round, bushy, much-branched plant growing 1 to 3 1/2 feet high whereas S. collina is relatively narrow and erect, smaller in size. The branches are slender, succulent when young and woody when mature. The leaves are alternate with the first ones being dark green, soft, slender, and 1 to 2 1/2 inches long. These drop off and later leaves are short, stiff, spiny, and not over 1/2 inch long, with two sharp-pointed bracts at the base. The flowers are small, inconspicuous, green-white or pink and are usually solitary in the leaf axils. The seeds are about 1/16 inch in diameter and conical with each enclosed in a calyx with a papery margin. At maturity, the plant breaks off at the base and because of its round shape becomes an excellent tumbleweed, scattering seeds for long distances. The young, green succulent plants are utilized for hay or forage when other food is scarce. It grows on the dry plains, in cultivated fields, and waste places, chiefly in grain-growing areas. It is widespread over Colorado up to 8,500 feet.

LARKSPUR, Geyer, low, or plains larkspur [*Delphinium geyeri*]. (p.73)

Crowfoot family. Larkspur is a native perennial with a woody tuberous root which produces an erect slightly hairy stem. The leaves are simple, alternate or clustered at the ground, petioled, and palmately lobed into three to five primary divisions which are again lobed and repeatedly divided into linear segments. The showy flowers occur in a terminal raceme, 1/2 to 2 feet tall, with five predominantly purple sepals. The upper sepal is prolonged backwards into a distinct spur. The individual seed pods are upright containing many dark seeds when ripe. While green, the entire plant is poisonous to cattle. The seeds are also toxic.

TALL LARKSPUR [*Delphinium barbeyi*]. (p. 73)

Crowfoot family. It is distinguished from plains larkspur because it (a) typically grows in higher mountain open moist areas, (b) is 2 to 5 feet tall, (c) is distinctly stemmed throughout most of the season, (d) flowers in the summer rather than spring, and (e) does not die back until fall. Tall larkspur is also a toxic plant, but is a less serious problem because it is less available to grazing cattle.

WHITETOP, hoary cress, whiteweed, perennial peppergrass [*Cardaria draba*]. (p.88)

Noxious. Mustard family. This weed was introduced from Europe probably in alfalfa seed. It is a native of Asia. It is a creeping perennial which reproduces by seeds and creeping roots. It grows erect from 10 to 18 inches high and has a gray-white color. The leaves clasp the stem and are oval or oblong with toothed or almost smooth margins. Each leaf is 1/2 to 2 inches long with blunt ends. The flowers are white, about 1/8 inch across and are numerous in compact flat-top clusters which give the plant its name. The seed pods are heart-shaped and each contains two oval, finely pitted, red-brown seeds each about 1/12 inch long. It grows in waste places and cultivated fields and is capable of vigorous growth on the irrigated, alkaline soils of the West. It is found in several

sections of the United States, but is especially bad in the Rocky Mountain region and on the West Coast. It occurs in cultivated areas over Colorado from 3,500 to 8,500 feet. The variety *repens* has definitely lens-shaped instead of heart-shaped seed pods, but intergradations are so common as to question the value of the distinction.

WILD CARAWAY [*Carum carvi*]. (p.111)

Carrot family. Wild caraway was introduced and escaped from cultivation. It is a biennial and the first year's growth is a leafy rosette. One or more stems emerge from a taproot the second year. The stems are erect, branching, smooth, furrowed, usually hollow, 1 to 2 and sometimes 3 feet tall. The leaves are alternate; the upper ones have a lacy appearance being finely divided into linear or threadlike segments. The lower leaves are coarser. The flowers are small, white, and occur in terminal or lateral, loose umbels. The seeds are narrow oblong, more or less curved, 1/8 inch or more long, and brown with five conspicuous tan, linear ribs. It invades mountain meadows in the western half of Colorado from 4,500 to 9,000 feet.

SHOWY MILKWEED [*Asclepias speciosa*]. (p.116)

Milkweed family. This native creeping perennial reproduces by seeds and horizontal roots. The stem is erect, stout, and unbranching, and grows 1 to 5 feet high. The plant is usually white-woolly all over with short, downy hairs. The leaves are opposite, thick, oblong to elongated egg-shaped, 3 to 8 inches long and gray-green. The flowers are purple or pink and borne in large umbels. The fruit is a spindleshaped follicle, 3 to 5 inches long. It is also white-woolly and covered with soft spines and contains many flat, corky-margined brown seeds, each 1/6 to 1/4 inch long and tipped with a tuft of silky hairs. The entire plant contains a milky juice. It grows in fields, pastures, and waste places but favors moist conditions. It is prevalent in northern and western United States and is widespread over Colorado from 3,500 to 7,500 feet.

FIELD BINDWEED, European bindweed, wild morningglory, small-flower morningglory, creeping-jenny, greenvine [*Convolvulus arvensis*]. (p.118)

Noxious. Morningglory family. This creeping perennial was introduced from Europe. It reproduces by seeds and horizontal roots. The stems are smooth, slender slightly angled, 1 to 4 feet long, and spread thickly over the ground or twine around erect plants or other objects. The leaves are alternate, 1 to 2 inches long with great variation in shape. They are more or less arrow-shaped with spreading, pointed, or blunt lobes at the base. The flowers are bell- or trumpet-shaped, white or pink, and about 3/4 to 1 inch broad. The fruit is a small, round capsule, usually four-seeded. The seeds are dull brown roughened by fine tubercles, pear-shaped, flattened on two sides, round on the other, and about 1/6 inch long. It may be the best known and most widely distributed of the noxious weeds. It grows in cultivated fields and waste places. It is distributed throughout the United States and the world. It is widespread in cultivated areas over Colorado from 4,000 to 8.000 feet.

HOUNDSTONGUE [*Cynoglossum officinale*]. (p.120)

Borage family. This biennial was introduced from Europe but is a native of Asia. It appears as a leafy rosette the first year. It reproduces by seeds. The stem is erect, stout heavy 1 1/2 to 3 feet

high and usually branched above. The leaves are alternate with the basal and lower ones broad, oblong to lance-shaped, 4 to 12 inches long, and 1 to 3 inches wide. The upper leaves are narrower, pointed, and almost clasping. The whole plant is covered with soft, white hairs. The flowers are red-purple (rarely white) and occur in long, sometimes branched terminal clusters. The fruit consists of four nutlets each about 1/4 to 1/3 inch long, with the outer surface covered with short, barbed prickles. The nutlets break apart at maturity and are readily scattered by livestock. It grows in fields, pastures, along roadsides, and in waste places. It is found in cultivated areas in Colorado from 5,000 to 9,000 feet.

YELLOW TOADFLAX, butter-and-eggs, wild snapdragon [*Linaria vulgaris*]. (p.138)

Noxious. Figwort family. This is an introduced creeping perennial. It is an escaped ornamental which reproduces by seeds and extensive horizontal roots. The stems are smooth, erect, leafy, often in clumps 1 to 2 1/2 feet tall. The leaves are alternate, narrow, pointed at both ends, and up to 2 1/2 or more inches long. The flowers resemble cultivated snapdragon. They are bright yellow with an orange throat and about an inch long. They occur in terminal, somewhat elongated clusters with the youngest flowers at the tip. The fruit is a brown, globe-shaped, two-celled capsule, 1/4 inch in diameter and contains many seeds. The seeds are small, round, rough, flattened notch-winged, dark brown, and about 1/12 inch in diameter. It is a persistent, aggressive invader. It grows in cultivated fields, meadows, gardens and waste places. In Colorado it usually grows from 6,000 to 8,500 feet and mostly on the Western Slope but is found on the eastern side of the mountains.

DALMATION TOADFLAX [*Linaria dalmatica*]. (p.138)

Noxious. Figwort family. It differs from yellow toadflax principally in being larger. The clumps of stems are 2 to 4 or more feet tall. The waxy leaves are broad, ovate, sometimes heartshaped and clasping the stem. The seeds are irregular in shape angular, somewhat flattened, thin-edged, strongly netted, tan-gray and 1/24 to 1/16 inch across. It is not as common, but probably more aggressive. It is reported from various parts of the state from 5,000 to 6,500 feet.

MAYWEED, dogfennel, chamomile [*Anthemis cotula*]. (p.153)

Aster family. Dogfennel tribe. Mayweed was introduced from Europe and is an annual or winter annual which reproduces by seed. The stem is smooth below, somewhat hairy above, slender, much branched and spreads to form a bushy plant, 1 to 2 feet tall. The leaves are alternate, 1 to 2 inches long, fernlike, being once, twice, or thrice pinnatifid. The flower heads are numerous, solitary at the ends of the branches, 1/2 to 1 inch across, and resemble daisies with 10 to 18 white, three-toothed ray flowers and a compact center of numerous yellow disk flowers. The achenes are oblong, 10-ribbed, roughened, light brown, and about 1/16 inch long. The plant is ill-smelling with a bitter taste and glandular secretions that may burn the skin. It is not eaten by livestock. It is widely distributed in fields, gardens, and waste places and is found in cultivated areas over Colorado from 5,000 to 9,500 feet.

SKELETONLEAF BURSAGE, silverleaf povertyweed, bur ragweed. [*Ambrosia tomentosa*]. (p.160)

Noxious. Aster family. Ragweed tribe. This is a native creeping perennial which reproduces by seeds and horizontal roots. The stem is 4 to 18 inches high, much branched, and somewhat bushy. The leaves are alternate, white beneath with minute hairs, smooth, green above, 2 to 5 inches long, and bipinnatifid into narrow, irregularly margined lobes or segments. The staminate flowers are in small drooping heads, usually in solitary, loose, elongated, terminal clusters. The pistillate flowers are usually in pairs in axils below. The fruit is a light brown bur, up to 1/4 inch long armed with conical spines, and containing one or more achenes. It grows in dry soil, prairies, pastures, waste places, and is a weed in cultivated and irrigated fields. It is common to the Plains region of the West. It is most common in northcentral, central, and northwestern Colorado from 5,000 to 8,000 feet, but is to be expected wherever land is cultivated.

COCKLEBUR, clotbur, sheepbur [*Xanthium strumarium*]. (p.161)

Aster family. Ragweed tribe. This native annual reproduces by seeds. It is a large, rough, branched plant, 1 to 3 1/2 feet tall, having thick, coarse stems with many brown spots. The leaves are alternate, rough and large, broadly ovate, with more or less wavy, toothed, or lobed margins. The staminate flowers occur in small, green, inconspicuous heads in loose clusters at the ends of the branches. The pistillate flowers are found below in dense clusters in the leaf axils and they develop into clusters of oblong burs, each 1/3 to 1 inch long covered with coarse, hooked spines with two heavier hooks at the end. Each bur contains two seeds, one of which usually germinates the first year after shedding and the other germinates the second year. The achenes are black, slightly ridged, narrow oblong, slightly flattened, and about 1/2 inch long. The seeds may remain viable in soil for several years. It is a bad weed any place but is especially bad in sheep country, where the burs contaminate wool. The seedlings are poisonous to livestock due to hydroquinone transmitted from the seed. It grows in cultivated fields, waste places, and along roadsides and is widely distributed. It is scattered over Colorado from 3,500 to 7,000 feet.

MOUSE-EAR POVERTYWEED, povertyweed, lesser marshelder, sumpweed [*Iva axillaris*]. (p.163)

Noxious. Aster family. Ragweed tribe. This is a native creeping perennial which reproduces by seeds and horizontal roots. The erect stem is much branched, 4 to 18 inches high and smooth or slightly hairy. The leaves are mainly opposite, numerous, sessile, entire, rather thick, narrowly oblong, entire margins, 1/2 to 1 1/4 inches long, rough-hairy, harsh and stiff to the touch. The flowers are in small heads which hang down on short stalks from the axils of the upper leaves. The achenes are deep gray to almost black, wedge-shaped, and 1/8 inch long. It grows in cultivated fields, meadows, and waste places, in saline and alkaline soils. It is scattered over Colorado from 3,500 to 7,500 feet.

WOOLLYLEAF POVERTYWEED, woollyleaf franseria, woollyleaf bursage, lagoonweed [*Ambrosia grayi*]. (p.164)

Noxious. Aster family. Ragweed tribe. This is a native creeping perennial which reproduces by seeds and horizontal roots. The stem is 1 to 2 1/2 feet high branches from the base, and is covered

with fine white-woolly hairs. The leaves are alternate white-woolly on both sides or gray above. They are usually three to seven-lobed with lobes or segments being lance-shaped, and usually toothed with the middle or terminal lobe the largest. The staminate flowers are in small drooping heads usually in solitary, loose, elongated, terminal clusters. The pistillate flowers are usually solitary in the leaf axils immediately below. The achenes are in a small bur about 1/4 inch or more long, awned with sharp, sometimes curved or hooked spines. It grows in moist, fertile soil, frequently starting in low wet places and spreading into adjacent cultivated areas. It is found in the western plains region and in eastern Colorado from 3,500 to 4,500 feet.

COMMON BURDOCK [*Arctium minus*]. (p.168)

Aster family. Thistle tribe. Burdock was introduced from Europe and is a biennial which reproduces by seeds. The first year's growth is a rosette of long petioled, large, alternate leaves which are simple and heart-shaped. The second year's growth is an erect, stout, grooved, rough-hairy, much branched stem which grows 2 to 6 feet high. The leaves are alternate, dark green, smooth above, whitegreen and woolly-hairy beneath, broadly ovate, blunt, and more or less heart-shaped, with somewhat wavy margins. The flowers are purple or white in numerous heads, on short pedicels or sessile in the upper leaf axils or at the ends of the branches. The flower is enclosed in a prickly involucre composed of numerous smooth or slightly woolly bracts tipped with hooked spines. The gray to brown mottled achenes are oblong, about 3/16 inch long flattened, and slightly curved. It is a serious weed on sheep range where the burs are very damaging to wool quality. It grows in moist fertile soil in neglected orchards, waste places, and along roadsides. It is found in central and north-central Colorado from 4,500 to 7,000 feet.

BULL THISTLE [*Cirsium vulgare*]. (p.170)

Aster family. Thistle tribe. Bull thistle was introduced from Europe but is a native of Asia. It is a biennial which reproduces by seeds. The stem is stout, erect, branched, more or less hairy, 2 to 5 feet high, and leafy to the heads. The leaves are alternate, the bases decurrent, stiff, hairy above, densely woolly-hairy beneath, more or less lance-shaped, 3 to 6 inches long, and deeply pinnatifid. The triangular to lance-shaped lobes are tipped with stout needlelike spines, the margins are bristly. The flowers are 1 to 2 inches broad, 1 to 2 inches long, and solitary on the ends of the branches. They are bright purple, fragrant, each surrounded by numerous imbricated, long, pointed bracts, each tipped with a slender, needlelike spine. The achenes are light colored, about 1/16 inch long, oblong, somewhat flattened, sometimes curved, with a long, white, hairy plume, which is easily detached. During the first year of growth the plant develops a deep taproot and a large spreading rosette made up of spiny lance-shaped, deeply pinnatifid leaves each 3 to 6 inches long or longer. It is scattered over Colorado.

CANADA THISTLE [*Cirsium arvense*]. (p.171)

Noxious. Aster family. Thistle tribe. Canada thistle was introduced from Europe and is a creeping perennial which reproduces by seeds and horizontal roots. The erect stem is hollow, smooth to slightly hairy, 1 to 4 feet tall, simple, and branched at the top. The leaves are set close on the stem, slightly clasping, very variable, typically smooth, green on both sides, sometimes white-hairy especially beneath, usually deeply and irregularly cut or pinnatifid into lobes or segments and tipped with sharp spines, or sometimes entire or nearly so. The typical thistle flowers

occur in numerous heads about 1/2 to 3/4 inch across and about 3/4 inch long, usually rose purple, sometimes lavender to white. All flowers on a plant are usually either male or female (dioecious) sometimes resulting in little or no seed production, when all the plants are of one kind. The achenes are tan, about 1/8 inch long, slightly flattened and curved, with a white, downy pappus, which is lightly attached. They sometimes blow free in large numbers. It grows in cultivated fields, pastures, meadows, roadsides, and waste places and is widely distributed in the northern half of the United States. It is distributed over Colorado from 4,000 to 9,500 feet.

MUSK THISTLE, bristle thistle [*Carduus nutans*]. (p.172)

Aster family. Thistle tribe. This is an introduced biennial, winter annual, or rarely annual which reproduces by seed. The first year's growth is a large compact rosette from a large, fleshy, corky taproot which is hollow near the soil surface. The second year stem is erect, spiny, 2 to 6 feet tall and branched at the top. The leaves are alternate, deeply cut or lobed with five points per lobe, very spiny, 3 to 6 inches long and extend (clasp) down the stem. The wavy leaves are dark green with a light green midrib and mostly white margins. Each leaf lobe ends in a prominent, stiff, white or yellow spine. The flowers are terminal flat, nodding, 1 1/2 to 21/2 inches broad, purple, rarely white, and subtended by numerous, lance-shaped, spine-tipped bracts. The achenes are over 1/8 inch long, striated, glossy, yellow-brown with a hairlike plume. It grows in pastures, roadsides, and waste places. It is an ever increasing problem in Colorado.

PLATTE THISTLE [*Cirsium canescens*]. (p.173)

Aster family. Thistle tribe. This is a native perennial with a deep fleshy taproot and it reproduces by seeds. The erect simple stem grows 1 to 3 1/2 feet high, is somewhat angled, and more or less covered with gray cottony hairs. The seedling rosette leaves are entire or slightly undulate and the leaves become more lobed with maturity. The decurrent leaves are 3 to 6 inches long, more or less soft, hairy tufted above, densely white-cottony beneath, and deeply divided into narrowly lance-shaped, acute lobes which are tipped with short, yellow-spines. The flowers are 1 to 2 inches across, solitary on the ends of branches, and are yellow-white. The involucre bracts are linear and tipped with yellow spines. The achenes are about 1/8 inch long, light brown, with a hairy plume. It grows in meadows, waste places, along roadsides and river bottoms in the western plains region and somewhat east. It is scattered over Colorado up to 9,000 feet.

SCOTCH THISTLE [*Onopordum acanthium*]. (p.174)

Aster family. Thistle tribe. Scotch thistle is a biennial or an annual which reproduces from seed and is a native of Eurasia. The first year rosettes are up to 10 or 12 inches in diameter and the leaves are large, coarsely lobed, green with a distinct white midrib. They are densely hairy on both sides and look gray-green. The stem is stout, leafy, usually much branched, and emerges from a large fleshy taproot. It is also white tomentose. The leaves are alternate, coarsely lobed, hairy on both sides and decurrent. The leaves are oblong in young plants and more nearly rectangular in older plants. They have prominent triangular lobes and the leaf and stem lobes end in a sharp green to white spine. Other smaller spines are present. The flowers are pale purple to red, flat, and are subtended by a series of imbricated bracts each tipped with a spine. The achenes are oblong to obovate, four-angled, deep brown to black and distinctly wrinkled. There is a

pappus of many capillary bristles which are never plumose. Scotch thistle blooms in June and July.

YELLOW STARTHISTLE [*Centaurea solstitialis*]. (p.176)

Aster family. Thistle tribe. This is an introduced annual which reproduces by seeds. The stem is white-woolly, branching from the base and above to form a bushy plant, 1 to 2 feet tall. The leaves are all white-woolly, deeply lobed, 2 to 3 inches long, with the upper ones much smaller, narrow, and more pointed. The flowers are yellow, about 1/2 inch across and 1 inch long. They are solitary at the ends of the branches and have outwardly pointed stiff yellow spines up to 1 inch long. The achenes are about 1/10 inch long and of two kinds. One is light colored with a soft pappus and the other is dark with no pappus. It is not common in Colorado but is found in the northern part around 5,000 feet. It is considered to be a serious weed in neighboring states.

ADDITIONAL WEEDS TO BE INCLUDED

The following list includes weeds that were designated by one or more counties but descriptions of these weeds were not found in the weed reference used.

Plumeless Thistle
Perennial Pepperweed
Whorled Milkweed
Purple Loosestrife
Sulfur Cinquefoil
Foothill Deathcamus
Orange Sneezeweed

OTHER COMMON NAMES USED FOR DESIGNATED WEEDS

Bristle thistle	See Musk thistle
Broomcorn millet	See Wild proso millet
Bur ragweed	See Skeletonleaf bursage
Butter-and-eggs	See Yellow toadflax
Chamomile	See Mayweed
Clotbur	See Cocklebur
Creeping-jenny	See Field bindweed
Dogfennel	See Mayweed
European bindweed	See Field bindweed
Fireweed	See Kochia
Geyer larkspur	See Larkspur
Greenvine	See Field bindweed
Hoary cress	See Whitetop
Lagoonweed	See Wollyleaf povertyweed
Lesser marshelder	See Mouse-ear povertyweed
Low larkspur	See Larkspur
Mexican fireweed	See Kochia
Perennial peppergrass	See Whitetop
Plains larkspur	See Larkspur
Povertyweed	See Mouse-ear povertyweed
Russian tumbleweed	See Russian thistle
Sheepbur	See Cocklebur
Silverleaf povertyweed	See Skeletonleaf bursage
Small-flower morningglory	See Field bindweed
Sumpweed	See Mouse-ear povertyweed
Tumbling thistle	See Russian thistle
Whiteweed	See Whitetop
Wild snapdragon	See Yellow toadflax
Wild morningglory	See Field bindweed
Woollyleaf bursage	See Wollyleaf povertyweed
Woollyleaf franseria	See Wollyleaf povertyweed

APPENDIX D. GLOSSARY

Achene - A small, dry, hard, one-seeded, fruit not opening at maturity.

Action Threshold - The point in time at which action must be taken to avoid reaching the damage threshold.

Annual weed - Weed that completes its life cycle (seed to seed) in one year.

Biennial weed - Weed that completes its life cycle (seed to seed) in two years.

Biological Control - The deliberate use of natural enemies to suppress plant populations. Natural enemies may be insects, mites, fungi, and ther plan pathogens. The result is not eradication but rather the reduction of a targeted weed population to a non-injurious important level.

Bract - A specialized leaf or leaflike part, usually situated at the base of a flower or inflorescence.

Chemical Control - Application of selective or nonselective herbicides.

Clear Zone - The clear zone is defined as Zone 1.

Containment - To confine a noxious weed in a specific geographical area.

Control - Prevention of seed production.

Cultural Control - The use of management tools such as:
Revegetation of disturbed soil
Use of fertilizer
Implementation of grazing management systems

Damage Thresholds - The point in the growth of a weed population when the numbers of weeds and/or locations are sufficient to cause some unacceptable degree of damage.

Direct Control Methods - Focus on the weeds themselves.

Dooryards -

Early Treatment - The control or eradication of specific weed species during the stage of invasion when both the locations and numbers of plants are few.

Ecologic Amplitude - The range of environmental conditions that an organism can tolerate within the scope of its requirements for life.

Eradication - A process that does not allow a species to produce propagules. The result of the process is the complete elimination of live plants. plant parts, and seeds of the target species from the area of infestation. Eradication always takes more than one season and normally takes many years (depending on seed viability/longevity).

Established Infestations - These are noxious weeds whose population levels and distribution are such that all seed production cannot be prevented in the County and/or land area. These species are so common or widespread that they have often exceeded damage thresholds or damage and action thresholds are often close.

Forb - Any herb that is not a grass or grasslike.

Habitat Modification - Changing the biophysical environment for purposes of: 1. reduction of weed habitat requirements, and 2. enhancement of the environment required by the weed's natural controls.

Habitat Requirements - The conditions an organism must have to survive.

Herbaceous Biomass -

Human Behavior Changes - Basic attitudes, beliefs and behavior patterns.

Indicator Sites - Specific sites where the likelihood or probability of a target weed species may be found.

Indicator Species - Plant species associated with any particular noxious weed.

Indirect Control Methods - Focus on the biophysical or "environmental", and the social or the human behavior aspects of the weed problem in an attempt to enhance the effect of natural controls on the weed, to modify human maintenance activities or attitudes, or otherwise modify the life support system of the weed.

Information Gathering - The process of surveying and monitoring. It is only as useful as its record keeping system is continual.

Integrated Weed Management (IWM) - A concept predicated on the fact that combined strategies for management are more effective in the long run than a single strategy.

Integration - All possible tactics used to affect the noxious weed population are integrated into a systematic approach to the problem. Integration also means the smooth interaction of all components outlined in this document to achieve the program's ultimate purpose: A co-existence between humans and noxious weeds that is satisfactory to the people involved and does not threaten the survival of the environment of which both humans and weeds are a part.

Involucre - A collection or rosette of bracts subtending a flower cluster, umbel, or the like.

Mechanical Control - Any physical means of weed removal including manual (handpulling/grubbing), mowing, cultivation, flooding, and mulching.

Mitigation - Actions taken to reduce, eliminate, or rectify the impacts of noxious weeds in currently infested areas.

Mites -

Monitoring - A process of gathering and recording site specific information. This information may then be used by the District when making choices about future treatment or no-action choices. As a component of IWM, monitoring means regularly inspecting the places in Douglas County where potential invaders are most likely to appear.

Nematodes -

New Invader - A noxious weed whose population level and distribution is such that all seed production can be prevented. A new invader has not spread to the point where it has reached the damage threshold. The action threshold (point at which control efforts would begin) is low.

Noxious Weed - Any exotic plant that when established is highly destructive, competitive, or difficult to control by cultural or chemical practices. Also this is a legal term assigned by legislation to such a plant.

Panicle - Any loose, diversely branching flower cluster.

Pappus- A downy, bristly, or otherwise tuftlike appendage of the achene of certain plants, as the dandelion and thistle.

Pathogens -

Perennial weed - Weed with a life cycle of more than one year.

Potential Invader - A noxious weed species as yet unrecorded in the County or Municipality, with an imminent potential for infestation.

Potential for off-site movement - Whether or not a weed species will spread off-site and impact other areas.

Post-emergent -

Pre-emergent -

Prevention - To detect and relieve the conditions that cause or favor the presence of competing or unwanted vegetation in the county. Prevention is in contrast with treatment which refers to activities for controlling or eradicating infestations of competing or unwanted vegetation. It also should not be confused with early treatment, which refers to activities for controlling or eradicating initial, small infestations of competing or unwanted vegetation before they interfere with the agency's objectives for managing that area or adjacent lands. It is the process of forestalling the contamination of an area by a noxious weed. Prevention includes the measures taken to forestall or hinder the introduction and spread of specific noxious weeds in areas not currently infested.

Reduction - A measurable decline between the first season project or treatment acreage with the current project or treatment acreage.

Rights-of-way (ROW) - All roads, gravel pits, borrow pits, utility corridors (phone. gas and transmission lines), railroads, irrigation ditchbanks, waterways and riparian zones.

Riparian -

Strategy - An overall approach to a problem, such as using "habitat management" to suppress a weed.

Suppression - The reduction of a weed population without the expectation of control or containment.

Tactic - A specific action or series of actions within a strategy.

Umbel - An inflorescence in which a number of flower stalks or pedicels, nearly equal in length, spread from a common center.

Ungulate - Pertaining to hoofed animals.

Weed Management Strategy - A group of tactics or methods for preventing or controlling weed populations. When dealing with noxious weeds, management strategies are necessarily based on ecological understanding.

Wetland - Any area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, assorted vegetation typically adapted for life in saturated soil conditions.

Window of Control - The time span during which the target species are most visible.

Xero - Prefix pertaining to a dry condition.