Risks of Pendimethalin Use to Federally Threatened Bay Checkerspot Butterfly (*Euphydryas editha bayensis*)

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List of Commonly Used Abbreviations and Nomenclature

µg/kg	Symbol for “micrograms per kilogram”
µg/L	Symbol for “micrograms per liter”
ºC	Symbol for “degrees Celsius”
AAPCO	Association of American Pesticide Control Officials
a.i.	Active Ingredient
AIMS	Avian Monitoring Information System
Acc#	Accession Number
amu	Atomic Mass Unit
BCB	Bay Checkerspot Butterfly
BCF	Bioconcentration Factor
BEAD	Biological and Economic Analysis Division
bw	Body Weight
CAM	Chemical Application Method
CARB	California Air Resources Board
AW	Alameda Whipsnake
CBD	Center for Biological Diversity
CCR	California Clapper Rail
CDPR	California Department of Pesticide Regulation
CDPR-PUR	California Department of Pesticide Regulation Pesticide Use Reporting Database
CFWS	California Freshwater Shrimp
CI	Confidence Interval
CL	Confidence Limit
CTS	California Tiger Salamander
CTS-CC	California Tiger Salamander Central California Distinct Population Segment
CTS-SB	California Tiger Salamander Santa Barbara County Distinct Population Segment
CTS-SC	California Tiger Salamander Sonoma County Distinct Population Segment
DS	Delta Smelt
EC	Emulsifiable Concentrate
EC_{05}	5% Effect Concentration
EC_{25}	25% Effect Concentration
EC_{50}	50% (or Median) Effect Concentration
ECOTOX	EPA managed database of Ecotoxicology data

EEC	Estimated Environmental Concentration
EFED	Environmental Fate and Effects Division
e.g.	Latin *exempli gratia* (“for example”)
EIM	Environmental Information Management System
EPI	Estimation Programs Interface
ESU	Evolutionarily significant unit
et al.	Latin *et alii* (“and others”)
etc.	Latin *et cetera* (“and the rest” or “and so forth”)
EXAMS	Exposure Analysis Modeling System
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FQPA	Food Quality Protection Act
ft	Feet
GENEEC	Generic Estimated Exposure Concentration model
HPLC	High Pressure Liquid Chromatography
IC_{05}	5% Inhibition Concentration
IC_{50}	50% (or median) Inhibition Concentration
i.e.	Latin for *id est* (“that is”)
IECV1.1	Individual Effect Chance Model Version 1.1
KABAM	K_{OW} (based) Aquatic BioAccumulation Model
kg	Kilogram(s)
kJ/mole	Kilojoules per mole
km	Kilometer(s)
K_{AW}	Air-water Partition Coefficient
Kd	Solid-water Distribution Coefficient
KF	Freundlich Solid-Water Distribution Coefficient
K_{OC}	Organic-carbon Partition Coefficient
K_{OW}	Octanol–water Partition Coefficient
LAA	Likely to Adversely Affect
lb a.i./A	Pound(s) of active ingredient per acre
LC_{50}	50% (or Median) Lethal Concentration
LD_{50}	50% (or Median) Lethal Dose
LOAEC	Lowest Observable Adverse Effect Concentration
LOAEL	Lowest Observable Adverse Effect Level
LOC	Level of Concern
LOD	Level of Detection
LOEC	Lowest Observable Effect Concentration

LOQ	Level of Quantitation
m	Meter(s)
MA	May Affect
MATC	Maximum Acceptable Toxicant Concentration
m^2/day	Square Meters per Days
ME	Microencapsulated
mg	Milligram(s)
mg/kg	Milligrams per kilogram (equivalent to ppm)
mg/L	Milligrams per liter (equivalent to ppm)
mi	Mile(s)
mmHg	Millimeter of mercury
MRID	Master Record Identification Number
MW	Molecular Weight
n/a	Not applicable
NASS	National Agricultural Statistics Service
NAWQA	National Water Quality Assessment
NCOD	National Contaminant Occurrence Database
NE	No Effect
NLAA	Not Likely to Adversely Affect
NLCD	National Land Cover Dataset
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAEC	No Observable Adverse Effect Concentration
NOAEL	No Observable Adverse Effect Level
NOEC	No Observable Effect Concentration
NRCS	Natural Resources Conservation Service
OPP	Office of Pesticide Programs
OPPTS	Office of Prevention, Pesticides and Toxic Substances
ORD	Office of Research and Development
PCE	Primary Constituent Element
pH	Symbol for the negative logarithm of the hydrogen ion activity in an aqueous solution, dimensionless
pKa	Symbol for the negative logarithm of the acid dissociation constant, dimensionless
ppb	Parts per Billion (equivalent to µg/L or µg/kg)
ppm	Parts per Million (equivalent to mg/L or mg/kg)

PRD	Pesticide Re-Evaluation Division
PRZM	Pesticide Root Zone Model
ROW	Right of Way
RQ	Risk Quotient
SFGS	San Francisco Garter Snake
SJKF	San Joaquine Kit Fox
SLN	Special Local Need
SMHM	Salt Marsh Harvest Mouse
TG	Tidewater Goby
T-HERPS	Terrestrial Herpetofaunal Exposure Residue Program Simulation
T-REX	Terrestrial Residue Exposure Model
UCL	Upper Confidence Limit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VELB	Valley Elderberry Longhorn Beetle
WP	Wettable Powder
wt	Weight

1. Executive Summary

1.1. Purpose of Assessment

The purpose of this assessment is to evaluate potential direct and indirect effects on the Bay Checkerspot Butterfly (BCB, *Euphydryas editha bayensis*) arising from FIFRA regulatory actions regarding use of pendimethalin on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in modification of designated critical habitat for the BCB. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998), procedures outlined in the Agency's Overview Document (USEPA, 2004), and consistent with a suit in which pendimethalin was alleged to be of concern to the BCB (*Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS).

- **Bay Checkerspot Butterfly (BCB):** The BCB was listed as threatened in 1987 by the USFWS. The species primarily inhabits native grasslands on serpentine outcrops around the San Francisco Bay Area in California.

1.2. Scope of Assessment

1.2.1. Uses Assessed

Pendimethalin is a selective herbicide registered for control of broadleaf weeds and grassy weed species on a variety of agricultural crops, turf, and ornamentals. The major agricultural crops for pendimethalin are soybean (2.6 million lbs a.i. annually), cotton (1.7 million lbs a.i. annually) and corn (1.5 million lbs a.i. annually). It is recognized that pendimethalin is used in many parts of the U.S., however, the scope of this assessment limits consideration of the areas of use that may be applicable to the protection of the SFBay and its designated critical habitat within the state of California. For a complete list of uses, please see Section 2. Pendimethalin disrupts the process of mitosis in the growth of shoots and roots. It acts as a microtubule disruptor by inhibiting cell division and cell elongation in plants, and is generally applied early in the growing season. Adsorption of the herbicide takes place at the roots and shoots but very little translocation occurs from the site of intake.

Pendimethalin is applied as an emulisifiable concentrate, capsulated suspension, or spreadable granule. Pendimethalin can be applied either by aerial or ground equipment to a variety of agricultural and non-agricultural sites. It can be sprayed by air or ground, and be banded as a directed spray or applied by irrigation equipment in various crops. It can also be left on the soil surface or incorporated. Although all potential uses are assessed, risks from ground boom and aerial applications are the focus of this assessment because they are expected to result in the highest off-target concentrations of pendimethalin.

The end result of the EPA pesticide registration process (the FIFRA regulatory action) is an approved product label. The label is a legal document that stipulates how and where a given pesticide may be used. Product labels (also known as end-use labels) describe the formulation type (*e.g.*, liquid or granular), acceptable methods of application, approved use sites, and any restrictions on how applications may be conducted. Thus, the use or potential use of pendimethalin in accordance with the approved product labels for California is "the action" being assessed. As a result of the life-history of the BCB, this assessment focuses on terrestrial exposure only.

Although current registrations of pendimethalin allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of pendimethalin in portions of the action area that are reasonably assumed to be biologically relevant to the SFBay species and their designated critical habitat. Further discussion of the action area for the SFBay species and their critical habitat is provided in Section 2.7.

Pendimethalin has registered products that contain multiple active ingredients. The results of this analysis suggest that a mixture of pendimethalin and propanil (Reg. Num. 5905-495) may be more toxic than pendimethalin TGAI (MRID 00143441); however, this information is still under review and may be subject to change. As a result of the ongoing review of mixture data, this assessment was conducted based on the toxicity of the single active ingredient of pendimethalin. In cases where mixtures are more toxic than the single active ingredient this assessment may underestimate risk.

1.2.2. Environmental Fate Properties of Pendimethalin

Pendimethalin dissipates in the environment by sorption to soil, metabolization by microbes, and by volatilization into air. Microbes can degrade pendimethalin to many non-significant (<l0 % of applied radio activity) degradates. Persistence in the terrestrial environment decreases with increasing temperature, moisture, or decreasing soil organic carbon because the extent of sorption of pendimethalin is related to soil organic content. Pendimethalin residues in field studies are tightly bound to soil and sediment particles, which is consistent with the laboratory mobility studies.

Pendimethalin is stable to hydrolysis, soil photolysis, anaerobic soil metabolism (98% stable after 60 days) and aerobic soil metabolism ($t_{1/2}$ = 1322 days). Pendimethalin degrades by aqueous photolysis ($t_{1/2}$ = 17 days), aerobic aquatic metabolism ($t_{1/2}$ = 27 days), and anaerobic aquatic metabolism ($t_{1/2}$ = 68 days).

Potential transport mechanisms for pendimethalin to the BCB include exposure at time of application and spray drift. Transport mechanisms for pendimethalin to terrestrial plants, especially those which have an obligate relationship with the BCB, include spray drift and surface water run-off. Secondary drift (atmospheric transport) of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems may also be possible given pendimethalin's relatively low solubility in water (0.275 mg/L), relatively high vapor pressure ($3.0x\ 10^{-5}$ torr) and Henry's law constant (4.04×10^{-5} atm-m^3/mol). Pendimethalin has been detected in surface water, air, rain and snow with detection values of 3.5 µg/L (surface water), 100 to 1,500 ng/L (rain), 0.64 to 3.6 mg/m3 (air), and 1,370 to 3,620 ng/L (fog).

1.2.3. Evaluation of Degradates and Stressors of Concern

Minor degradates (<10%) include four alcohol metabolites, two acid metabolites, and one dinitroaro-matic amine metabolite (2,6-dinitro-3,4-dimethylaniline). These degradates were not considered independently for direct or indirect exposure to the BCB. More information on degradates is provided in the Problem Formulation Section below.

1.3. Assessment Procedures

A description of routine procedures for evaluating risk to the San Francisco Bay Species are provided in Attachment I.

1.3.1. Exposure Assessment

1.3.1.a. Terrestrial Exposures

To estimate pendimethalin exposures to terrestrial species resulting from uses involving pendimethalin applications, the T-REX model is used for foliar uses. The AgDRIFT model is also used to estimate deposition of pendimethalin on terrestrial habitats from spray drift.

1.3.2. Toxicity Assessment

The assessment endpoints include direct toxic effects on survival, reproduction, and growth of individuals, as well as indirect effects, such as reduction of the food source and/or modification of habitat. Federally-designated critical habitat has been established for the BCB. Primary constituent elements (PCEs) were used to evaluate whether pendimethalin has the potential to modify designated critical habitat. The Agency evaluated registrant-submitted studies and data from the open literature (where available) to characterize pendimethalin toxicity. The most sensitive toxicity value available from acceptable or supplemental studies for each taxon relevant for estimating potential risks to the assessed species and/or their designated critical habitat was used.

Section 4 summarizes the ecotoxicity data available on pendimethalin. Pendimethalin is slightly toxic to practically non-toxic to birds on an acute oral and subacute dietary exposure basis, respectively. It is slightly toxic to mammals on an acute oral exposure basis. Pendiemthalin has reproductive effects on birds and mammals, affecting number of eggs and offspring produced as well as pup body weight in subsequent generations at 140 (bird) and 125 (rat) mg a.i./kg-diet concentrations, respectively. Pendimethalin is classified as practically non-toxic to honey bees on an acute contact exposure basis. Pendimethalin, as a pre-emergent herbicide, is toxic to plants at both the seedling emergence and vegetative vigor life-stages. No effect concentrations for terrestrial plants range from 0.0008 to 0.063 lbs a.i./A. Pendimethalin is also toxic to both vascular and non-vascular aquatic plants, with no effect concentrations of 5.6 and 0.7 µg a.i./L, respectively.

1.3.3. Measures of Risk

Acute and chronic risk quotients (RQs) are compared to the Agency's Levels of Concern (LOCs) to identify instances where pendimethalin use has the potential to adversely affect the assessed species or adversely modify their designated critical habitat. When RQs for a particular type of effect are below LOCs, the pesticide is considered to have "no effect" on the species and its designated critical habitat. Where RQs exceed LOCs, a potential to cause adverse effects or habitat modification is identified, leading to a conclusion of "may affect". If pendimethalin use "may affect" the assessed species, and/or may cause effects to designated critical habitat, the best available additional information is considered to refine the potential for exposure and effects, and distinguish actions that are Not Likely to Adversely Affect (NLAA) from those that are Likely to Adversely Affect (LAA).

1.4. Summary of Conclusions

In fulfilling its obligations under Section 7(a)(2) of the Endangered Species Act, the information presented in this endangered species risk assessment represents the best data currently available to assess the potential risks of pendimethalin BCB.

Based on the best available information, the Agency makes a May Affect, Likely to Adversely Affect determination for the BCB. Additionally, the Agency has determined there is a potential for modification of the designated critical habitat for the BCB from the use of the chemical. Given the LAA determination and potential modification of designated critical habitat for BCB a description of the baseline status and cumulative effects is provided in Attachment III.

A summary of the risk conclusions and effects determinations for the BCB and its critical habitat, given the uncertainties discussed in Section 6 and Attachment I, is presented in **Table 1-1** and **Table 1-2**. Use specific effects determinations are provided in **Table 1-3**.

Table 1-1. Effects Determination Summary for Effects of Pendimethalin on the BCB

Species	Effects Determination	Basis for Determination
Bay Checkerspot Butterfly (*Euphydryas editha bayensis*)	May Affect, Likely to Adversely Affect (LAA)	**Potential for Direct Effects** • While potential for direct effects is uncertain given the lack of acceptable toxicity data at environmentally relevant exposure concentrations, evidence suggests risks to the BCB are likely. • The species critical habitat and/or occurrence sections overlap with the use footprint • Probability of individual effect (based on honey bee toxicity data) is 1 in 1 **Potential for Indirect Effects** • Habitat modification resulting from potential effects to obligate plant species of the BCB (dwarf plantain, purple owl's clover, and exserted paintbrush) • The species critical habitat and/or occurrence sections overlap with the use footprint

Table 1-2. Effects Determination Summary for the Critical Habitat Impact Analysis

Designated Critical Habitat for:	Effects Determination	Basis for Determination
Bay Checkerspot Butterfly (*Euphydryas editha bayensis*)	Habitat Modification	• While potential for direct effects is uncertain given the lack of acceptable toxicity data at environmentally relevant exposure concentrations, evidence suggests risks to the BCB are likely. • Risk to terrestrial plants and thus BCB habitat (esp. plants with obligate relationship to the BCB including, dwarf plantain, purple owl's clover, exserted paintbrush) was assumed. • Area of overlap between species habitat/critical habitat/ or occurrence sections and the use footprint

Table 1-3. Use Specific Summary of the Potential for Adverse Effects to Terrestrial Taxa

Uses	Potential for Effects to Identified Taxa Found in the Terrestrial Environment:		
	BCB and Invertebrates (Acute)[1]	Dicots[2]	Monocots[2]
Citrus; Nut crops; Grapes	Yes	Yes	Yes
Pome fruits; Sugarcane	Yes	Yes	Yes
Stone fruits; Leafy and stem vegetables; Forage grasses; Various non-agricultural uses[1]	Yes	Yes	Yes
Uncultivated agricultural areas (fallow land); Turfgrass (golf course, non-residential, commercial)	Yes	Yes	Yes
Corn; Cotton; Soybeans; Residential turfgrass; Sod farms	Yes	Yes	Yes
Fruiting vegetables; Root crop vegetables; Legumes; Grain crops; Sunflowers	Yes	Yes	Yes
Rice; brassica head and stem vegetables, brassica leafy greens	Yes	Yes	Yes

[1] A yes in this column indicates a potential for direct effect to BCB.

[2] A yes in this column indicates a potential for indirect effects to BCB. For the BCB this is based on the listed species LOC because of the obligate relationship with terrestrial monocots and dicots.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated.

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the listed species and its resources (*i.e.*, food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (*i.e.*, attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of BCB life stages within the action area and/or applicable designated critical habitat. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the assessed species.
- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.
- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual species and potential modification to critical habitat.

2. Problem Formulation

Problem formulation provides a strategic framework for the risk assessment. By identifying the important components of the problem, it focuses the assessment on the most relevant life history stages, habitat components, chemical properties, exposure routes, and endpoints. The structure

of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (USEPA, 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998) and is consistent with procedures and methodology outlined in the Overview Document (USEPA, 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS/NOAA, 2004).

2.1. Purpose

The purpose of this endangered species assessment is to evaluate potential direct and indirect effects on individuals of the BCB arising from FIFRA regulatory actions regarding use of pendimethalin on a variety of agricultural and non agricultural uses. This ecological risk assessment has been prepared consistent with a stipulated injunction in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS) entered in Federal District Court for the Northern District of California on May 17, 2010.

In this assessment, direct and indirect effects to the BCB and potential modification to BCB's designated critical habitat are evaluated in accordance with the methods described in the Agency's Overview Document (USEPA, 2004).

- **Bay Checkerspot Butterfly (BCB):** The PCEs for BCBs are areas on serpentinite-derived soils that support the primary larval host plant (*i.e*., dwarf plantain) and at least one of the species' secondary host plants. Additional BCB PCE's include the presence of adult nectar sources, aquatic features that provide moisture during the spring drought, and areas that provide adequate shelter during the summer diapause.

In accordance with the Overview Document, provisions of the ESA, and the Services' *Endangered Species Consultation Handbook*, the assessment of effects associated with registrations of pendimethalin is based on an action area. The action area is the area directly or indirectly affected by the federal action, as indicated by the exceedance of the Agency's Levels of Concern (LOCs). It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of pendimethalin may potentially involve numerous areas throughout the United States and its Territories. However, for the purposes of this assessment, attention will be focused on relevant sections of the action area including those geographic areas associated with locations of the BCB and their designated critical habitat within the state of California. As part of the "effects determination," one of the following three conclusions will be reached separately for each of the assessed species in the lawsuits regarding the potential use of pendimethalin in accordance with current labels:

- "No effect";
- "May affect, but not likely to adversely affect"; or
- "May affect and likely to adversely affect".

Additionally, for habitat and PCEs, a "No Effect" or a "Habitat Modification" determination is made.

A description of routine procedures for evaluating risk to the San Francisco Bay Species is provided in Attachment I.

2.2. Scope

Pendimethalin is a selective herbicide registered for control of broadleaf grassy weed species on a veriety of agricultural crops, turf and ornamentals. Estimates of pendimethalin usage indicate that it is used extensively on soybean, cotton and corn. It is recognized that pendimethalin is used in many parts of the U.S.; however, the scope of this assessment limits consideration of the areas of use that may be applicable to the protection of the BCB and its designated critical habitat within the state of California.

Pendimethalin is formulated mainly as soluble concentrates. Application methods for the agricultural uses of pendimetalin include aircraft, band sprayer, spreader, chemigation, hand-held sprayer, high and low volume ground sprayer, and soil incorporation. Although all potential uses are assessed, risks from ground boom and aerial applications are the focus of this assessment because they are expected to result in the highest off-target concentrations of pendimethalin.

The end result of the EPA pesticide registration process (*i.e.*, the FIFRA regulatory action) is an approved product label. The label is a legal document that stipulates how and where a given pesticide may be used. Product labels (also known as end-use labels) describe the formulation type (*e.g.*, liquid or granular), acceptable methods of application, approved use sites, and any restrictions on how applications may be conducted. Thus, the use or potential use of pendimethalin in accordance with the approved product labels for California is "the action" relevant to this ecological risk assessment.

Although current registrations of pendimethalin allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of pendimethalin in portions of the action area that are reasonably assumed to be biologically relevant to the BCB and its designated critical habitat. Further discussion of the action area for the BCB species and its critical habitat is provided in Section 2.7.

2.2.1. Evaluation of Degradates and Other Stressors of Concern

Minor degradates (<10%) include four alcohol metabolites, two acid metabolites, and one dinitroaro-matic amine metabolite (2,6-dinitro-3,4-dimethylaniline). Based on an analysis in the Ecological Structure Activity Relationships (Ecosar v 1.0) program, the alcohol metabolites have equal or greater toxicity to the parent for chronic freshwater fish, acute estuarine/marine fish, and chronic estuarine/marine fish. The acid metabolites and the dinitromethylamine metabolite have lesser toxixcity than the parent. While this information would be used in a Total Toxic Residue approach to refine an aquatic risk assessment, terrestrial risk assessments do not consider degradates separately. Since this assessment focuses on terrestrial exposure to the BCB, the parent, pendimethalin, will be considered.

2.2.2. Evaluation of Mixtures

The Agency does not routinely include, in its risk assessments, an evaluation of mixtures of active ingredients, either those mixtures of multiple active ingredients in product formulations or those in the applicator's tank. In the case of the product formulations of active ingredients (that is, a registered product containing more than one active ingredient), each active ingredient is subject to an individual risk assessment for regulatory decision regarding the active ingredient on a particular use site. If effects data are available for a formulated product containing more than one active ingredient, they may be used qualitatively or quantitatively in accordance with the Agency's Overview Document and the Services' Evaluation Memorandum (U.S., EPA 2004; USFWS/NMFS 2004).

Pendimethalin has registered products that contain multiple active ingredients. Analysis of the available acute oral mammalian LD_{50} data for multiple active ingredient products relative to the single active ingredient is provided in **APPENDIX A**. The results of this analysis suggest that a mixture of pendimethalin and propanil (Reg. Num. 5905-495) may be more toxic than pendimethalin TGAI by a factor of two (MRID 00143441; in review); however, evidence suggests that this increased toxicity can be attributed to propanil. However, because the active ingredients are not expected to have similar mechanisms of actions, metabolites, or toxicokinetic behavior, it is reasonable to conclude that an assumption of dose-addition would not be appropriate. Therefore, this assessment was conducted based on the toxicity of the single active ingredient of pendimethalin.

2.3. Previous Assessments

Pendimethalin was patented by American Cyanamid in 1972 and first registered in the U.S. in 1974. Pendimethalin is a dinitroaniline herbicide which selectively controls certain broadleaf weeds and grassy weed species in certain crop and non-crop areas. It is applied to soil pre-plant, pre-emergence, and post-emergence, with ground and aerial equipment.
The Reregistration Eligibility Decision Document [RED], published in June 1997, concluded that uses of pendimethalin would not cause unreasonable risks to the environment, though risks were identified for listed and non-listed fish and aquatic invertebrates as well as terrestrial and aquatic plants and listed and non-listed birds and mammals.

Pendimethalin is currently registered for use on a variety of agricultural crops, turf, and ornamentals. It can be broadcasted by air or ground and/or be banded as a directed spray or applied via irrigation equipment. Currently registered maximum single application rates of pendimethalin range from approximately 1 to 6 lb a.i./A with a seasonal application rates range from 4 to 6 lb a.i./A. Recent pendimethalin ecological risk assessments include the litigation-related California red-legged frog (CRLF) assessment (USEPA, 2009), a Section 3 new use assessment for artichoke, asparagus, brassica subgroup 5a, and grapes (USEPA, 2007; DP 334069) and a Section 3 new use assessment for edamame and cold- and warm-weather forage grass (USEPA, 2010; DP 378514). Additional assessments specific to Pacific Northwest fish species include the analysis of risks to endangered or threatened salmon and steelhead fish (USEPA, 2004) and the National Marine Fisheries Service (NMFS) Biological Opinion for

Pacific Salmon and Steelhead species (NMFS, 2012) (for more information go to www.epa.gov/espp/).

The most recent review performed for pendimethalin was the Section 3 New Use registration for use on leaf lettuce, brassica leafy greens subgroup 5B, turnip greens, melon subgroup 9A, succulent soybean (edamame) and small fruit vine climbing subgroup 13-07E except grapes (DP 391166 and DP 391167, March 20012). The screening-level risk assessment indicated that pendimethalin on these crops has the potential for direct acute effects to listed freshwater fish, estuarine/marine fish, estuarine/marine invertebrates, and aquatic vascular and non-vascular plants (including risk to non-listed aquatic non-vascular plants). With respect to terrestrial animals, direct acute and chronic effects to listed and non-listed birds and mammals are possible. In addition, acute and chronic effects to piscivorous birds and mammals via ingestion of pendimethalin residues in aquatic biota may be possible; however, depuration of pendimethalin was observed in the submitted bluegill sunfish study, which may reduce the potential for bioaccumulation. Risks to terrestrial plants are also predicted. Risks to terrestrial invertebrates are not expected.

2.4. Environmental Fate Properties

As discussed previously this assessment focuses on terrestrial exposure and risk because of the life history of the BCB and its food items.

Pendimethalin dissipates in the environment by sorption to soil, metabolization by microbes, and by volatilization into air. Microbes can degrade pendimethalin to many non-significant (<l0 % of applied radio activity) degradates. Also, the volatilization can be significant because pendimethalin has very limited water solubility, relatively high vapor pressure, and a high log K_{ow}. Persistence in the terrestrial environment decreases with increasing temperature, moisture, or decreasing soil organic carbon because the extent of sorption of pendimethalin is related to soil organic content. Pendimethalin residues in field studies are tightly bound to soil and sediment particles, which is consistent with the laboratory mobility studies.

Pendimethalin degraded in one soil and under aerobic soil conditions with a half-life of 1322 days. Terrestrial field dissipation data that are consistent with laboratory data have also been provided. In an Indiana field dissipation study, the half-lives ranged from 84-147 days. However, in field dissipation studies in Louisiana (LA) and Mississippi (MS), the half-lives ranged from 4 to 82 days, with most studies containing half-lives of <20 days. The difference in half-lives between LA/MS and Indiana can be attributed to the soil and climatic differences between the two locations. No leaching was observed in the field dissipation studies, which is consistent with the results of laboratory studies.

Pendimethalin has been detected in air, rain, and snow, according to a compilation of studies by Majewski and Capel (1995). Pendimethalin was analyzed in at least ten sites, with detection values of 100 to 1,500 ng/L (rain), 0.64 to 3.6 mg/m3 (air), and 1,370 to 3,620 ng/L (fog).

Pendimethalin is stable to hydrolysis, soil photolysis, and anaerobic soil metabolism but degrades by aqueous photolysis with a calculated half-life of 17 days. Pendimethalin degrades slowly due to anaerobic aquatic metabolism with a half-life of 68 days. Aqueous residues of parent pendimethalin and its degradates bind to sediment in anaerobic aquatic metabolism and soil mobility studies. Pendimethalin degraded under aerobic aquatic conditions (MRID 47385201) with a half-life of 27 days. The half-life in the aquatic field dissipation study (MRID 44527601) was 15 days, and virtually all residues were present in the top layer of soil once the rice field was flooded.

Pendimethalin accumulated readily in bluegill sunfish with bioconcentration factors (BCFs) of 1400X in edible portions, 5800X in non-edible portions, and 5100X in whole fish. Of labeled ^{14}C-pendimethalin taken up by fish, depuration of 87-91% of the 14C-residues occurred by 14 days post exposure.

Minor degradates (<10%) include four alcohol metabolites, two acid metabolites, and one dinitroaro-matic amine metabolite (2,6-dinitro-3,4-dimethylaniline).

Table 2-1 and **Table 2-2** lists the physical-chemical properties of pendimethalin. Please see Section 3 for further discussion on the environmental fate and transport properties of pendimethalin.

Table 2-1. Physical-chemical Properties of Pendimethalin

Property	Parent Compound	
	Value and units	**MRID or Source**
Molecular Weight	281.31 g/mol	Product chemistry (calculated)
Chemical Formula	$C_{13}H_{19}N_3O_4$	Product chemistry
Vapor Pressure	3.0×10^{-5} mmHg	MRID 00153766
Henry's Law Constant	4.04×10^{-5} atm-m^3/mole	Estimated from water solubility and vapor pressure
Water Solubility	0.275 mg/L @ 20^{o}C	MRID 46861302
Octanol – water partition coefficient (K_{OW})	152,000	Foot Print Pesticide Database @http://sitem.herts.ac.uk/aeru/footprint/en/index.htm

Table 2-2. Summary of Pendimethalin Environmental Fate Properties

Study	Value (units)	Major Degradates *Minor Degradates*	MRID #
Hydrolysis	Stable	None	00106777
Direct Aqueous Photolysis	Dark corrected, continuous irradiation half-life 21 days; 12-hour light/dark half-life 42 days.	37 minor, unidentified degradates *2,6-dinitro-3,4dimethylaniline* (9.3% of applied)	00153763 43808201
Soil Photolysis	Stable	None	00153764

Aerobic Soil Metabolism	1322 days (log linear calculations)	*2,6-dinitro3,4-xylidine 4-[(1-ethylpropyl)amino]-2methyl-3,5-dinitrobenzyl alcohol 4-[(1-ethylpropyl)amino]-2methyl-3,5-dinitro-o-toluic acid*	40185104
Anaerobic Soil Metabolism	Stable 98% parent at 60 days	*2,6-dinitro3,4-xylidine 4-[(1-ethylpropyl)amino]-2methyl-3,5-dinitrobenzyl alcohol 4-[(1-ethylpropyl)amino]-2methyl3,5-dinitro-o-toluic acid*	40185105
Anaerobic Aquatic Metabolism	68-day half-life (upper 90$_{th}$ %ile confidence bound on mean)	None	40813501 43154702
Aerobic Aquatic Metabolism	27 X 3 (81 days)	None	47385201
$K_{d\text{-}ads}$ / $K_{d\text{-}des}$ (mL/g) $K_{oc\text{-}ads}$ / $K_{oc\text{-}des}$ (mL/g)	30 – 854 (U.S. soils) 61 – 285 (Japanese soils) 17,040 mL/g O.C. (U.S. soils) (avg of 5 values, 13000 – 29400) 7011- 43863 mL/g o.c. (Japanese soils)	N/A	00153765 43041901
Laboratory Volatility	Volatilization half-life 12.5 days from moist loam soil	None measured	00153766
Fish Bioaccumulation	Bioconcentration factor BCF = 5100, 35-day exposure	*4-[(1-ethylpropyl)amino]-2-methyl-3,5-dinitrobenzyl alcohol (3.1%)*	00156726 00158235

Abbreviations: wt=weight

[1]Half-lives were calculated using the single-first order equation and nonlinear regression, unless otherwise specified.

[2]The value may reflect both dissipation and degradation processes.

2.4.1. Environmental Transport Mechanisms

Potential transport mechanisms for pendimethalin to the BCB include exposure at time of application and spray drift. Transport mechanisms for pendimethalin to terrestrial plants, especially those which have an obligate relationship with the BCB, include spray drift and surface water run-off. Secondary drift (atmospheric transport) of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems is possible given pendimethalin's relatively low solubility (0.275 mg/L) high vapor pressor (3.0×10^{-5} mmHg) and Henry's Law constant (4.04×10^{-5} atm-m^3/mole). The Association of American Pesticide Control Officials (AAPCO) report in the 1999 Pesticide Enforcement Survey (http://aapco.ceris.purdue.edu/doc/surveys/drift99.html) that pendimethalin is one of the least

commonly confirmed active ingredient by state agencies as regards to drift complaints (2,4-D, atrazine, dicamba, paraquat and glyphosate were the most common). However, the survey does not provide information on the magnitude of exposure arising from these reports, does not differentiate between drift and volatility, and indicates that the most common confirmation technique is visual examination of drift and residue confirmation.

Air monitoring data collected from the 1960s through the 1980s, and summarized by Majewski and Capel (1995), indicate the presence of pendimethalin in the atmosphere. Pendimethalin was analyzed in at least ten sites, with detection values of 100 to 1,500 ng/L (rain), 0.64 to 3.6 mg/m3 (air), and 1,370 to 3,620 ng/L (fog).

In general, deposition of drifting or volatilized pesticides is expected to be greatest close to the site of application. Computer models of spray drift (AgDRIFT) are used to determine potential exposures to aquatic and terrestrial organisms via spray drift. The distance of potential impact away from the use sites (action area) is determined by the distance required to fall below the LOC for the taxonomic group that has the largest RQ to LOC ratio, which for this assessment is 0.032 (**Section 5.2.4.a**).

2.4.2. Mechanism of Action

Pendimethalin is a selective herbicide registered for control of broadleaf weeds and grassy weed species on a variety of agricultural crops, turf, and ornamentals. Pendimethalin disrupts the process of mitosis in the growth of shoots and roots. It acts as a microtubule disruptor by inhibiting cell division and cell elongation in plants, and is generally applied early in the growing season. Adsorption of the herbicide takes place at the roots and shoots. Very little translocation occurs from the site of intake.

2.4.3. Use Characterization

Analysis of labeled use information is the critical first step in evaluating the federal action. The current labels for pendimethalin represent the FIFRA regulatory action; therefore, labeled use and application rates specified on the label form the basis of this assessment. The assessment of use information is critical to the development of the action area and selection of appropriate modeling scenarios and inputs.

Pendimethalin is currently registered for use on a wide variety of agricultural sites including field, vegetable, and orchard crops; turf; forestry; rights of way (**Table 2-3)**. There are currently 83 Section 3 registered products as well as 20 Special Local Needs (SLN) registrations for pendimethalin (see **Table 2-4** for a summary of products).

Table 2-3. Summary of Current Pendimethalin Uses.

Use Category	Uses
Agricultural	Flavoring and spice crops, fruiting vetegables, leafy and stem vegetables, root crop vegetables, forage grasses, legumes, grain crops, sugarcane, tobacco, corn, coton, peanuts, sunflowers, soybeans, asparagus, onions, rice, grapes,

	strawberries, figs, loquat.
Orchard	Almond, apple, apricot, cherry, chestnut, citrus, fig, grapefruit, kiwi, lemon, nectarines, olive, oranges, peaches, pears (northeastern U.S. only), pecans (southeastern U.S. only), plum, pomegranates, prune, tangelo, tangerine.
Non-Agricultural	Airports and landing fields, around buildings (commercial, industrial, institutional), around paved areas, lawns (commercial, industrial, recreational, residential), rights-of-way, fencerows, hedgerows, uncultivated agricultural areas (fallow land), golf courses, forestry, rangeland, sod farms, christmas tree plantations, ornamental nurseries.

There are a total of 21 formulated products containing pendimethalin. Of the 21 products, two are SLNs, both of which can be used in California.

Table 2-4 provides a complete listing of the 19 section 3 end-use products and the two SLNs. The table includes the formulation, EPA registration number, date of stamped label, % active ingredient, methods of application, and any relevant use restrictions.

Table 2-4. Currently Registered Pendimethalin End-Use Products.

FORMULATION	EPA REG. NO. (date latest label)	% ACTIVE	METHODS OF APPLICATION	USE RESTRICTIONS
DREXEL PENDIGUARD 0.75%	019713-00614 (10/21/2008)	0.75%	Soil incorporation, bulb treatment, spreader	None
DREXEL PENDIGUARD 0.86%	019713-00615 (10/21/2008)	0.86%	Soil incorporation, bulb treatment, spreader	None
DREXEL PEDNIGUARD TURF FERTILIZER	019713-00579 (12/27/2005)	0.66%	Broadcast, bulb treatmen	None
IPIMETHALIN-L	068156-00006 (8/9/2007)	37.4%	Aircraft, ground, irrigation, spreader, sprinkler irrigation, soil incorporation, band sprayer, center pivot irrigation	None
PENDI T&O 3.3 EC	019716-00590 (6/27/2006)	37.4%	Low pressure ground sprayer, ground sprayer, backpack sprayer, soil incorporation	None
PENDULUM	000241-	0.5%	Spreader, soil	None

FORMULATION	EPA REG. NO. (date latest label)	% ACTIVE	METHODS OF APPLICATION	USE RESTRICTIONS
0.5% PLUS FERTILIZER	00423 (8/31/2006)		incorporation	
PENDULUM 0.66% PLUS FERTILIZER	000241-00421 (8/31/2006)	0.66%	Spreader, soil incorporation	None
PENDULUM 0.86% PLUS FERTILIZER	000241-00424 (8/31/2006)	0.86%	Spreader, soil incorporation	None
PENDULUM 1.15% PLUS FERTILIZER	000241-00422 (8/31/2006)	0.86%	Spreader, soil incorporation	None
PENDULUM 2G GRANULE HERBICIDE	000241-00375 (4/3/2001)	2%	Spreader, soil incorporation	None
PENDULUM 3.3 HERBICIDE	000241-00391 (4/28/1998)	36.4%	Low pressure ground sprayer, backpack sprayer, hand held sprayer	None
PENDULUM CS HERBICIDE	000241-00416 (10/15/2003)	38.7%	Ground, backpack sprayer, hand held sprayer	None
PRE-M 3.3 EC TURF HERBICIDE	000241-00360 (9/1/2005)	37.4%	Aircraft, low pressure ground sprayer, ground,	None
PROWL 3.3 EC HERBICIDE	000241-00337 (1/2/2008)	37.4%	Aircraft, ground, irrigation, soil incorporation, spreader, sprinkler irrigation, sprayer, band sprayer	Restrictions in California on cotton, lentils, peanuts, peas, peppermint, soybeans, sunflower Restriction in HI
PROWL H2O HERBICIDE Includes SLN: CA06002100 (use on alfalfa) CA01002600 (use on rice)	000241-00418 (3/24/2008)	38.7%	Aircraft, gravity irrigation, ground, sprinkler irrigation, soil incorporation, center pivot irrigation, band sprayer	Restrictions in California on cotton, lentils, peanuts, peas, peppermint, rice, soybeans, spearmint, sunflower Restrictions in HI
PURSUIT PLUS EC HERBICIDE	000241-00331 (8/18/2008)	30.24%	Aircraft, ground, spreader, soil incorporation	Restrictions in ND and MN

FORMULATION	EPA REG. NO. (date latest label)	% ACTIVE	METHODS OF APPLICATION	USE RESTRICTIONS
SCEPTER HERBICIDE	000241-00376 (6/14/2002)	25.4%	Aircraft, ground, soil incorporation, sprayer	Not allowed in CA
SQUADRON NF HERBICIDE	000241-00327 (2/6/2006)	21.96%	Aircraft, ground, soil incorporation, spreader	Not allowed in CA
STOMP 3.3 EC HERBICIDE	000241-00341 (7/12/2007)	37.4%	Low pressure ground sprayer, hand held spreayer,	None

Pendimethalin is a liquid spray formulation registered for use on a wide variety of sites including field, vegetable, and orchard crops; turf (sod farms only); animal premises; commercial premises; and rights of way. For the purposes of this assessment 'agricultural uses' refer to all field and vegetable crops and sod farms. Orchard uses are analyzed separately from other agricultural uses because of their different use patterns.

Table 2-5 presents the range of uses and corresponding application rates and methods of application considered in this assessment.

Table 2-5. Pendimethalin Uses Assessed for California

Use	Maximum App. Rate	Maximum Seasonal Rate	Maximum Number of App.[1]	Minimum Retreatment Interval (days)
Citrus; Nut crops; Grapes	6.00 lb a.i./A	6.00 lb a.i./A	1	30
Pome fruits; Sugarcane	4.00 lb a.i./A	6.00 lb a.i./A	1	NS
Stone fruits; Leafy and stem vegetables; Forage grasses; Various non-agricultural uses[2]	4.00 lb a.i./A	4.00 lb a.i./A	1	30
Uncultivated agricultural areas (fallow land); Turfgrass (golf course, non-residential, commercial)	3.00 lbs a.i/A	3.00 lbs a.i./A	1	NA
Corn; Cotton; Soybeans; Residential turfgrass; Sod farms	2.00 lb a.i./A	2.00 lb a.i./A	1	NS
Fruiting vegetables; Root crop vegetables; Legumes; Grain crops; Sunflowers	1.50 lb a.i./A	1.50 lb a.i./A	1	NS
Rice; brassica head and stem vegetables, brassica leafy greens	1.00 lb a.i./A	NS	1	NS

Abbreviations: App. = applications; NS = not specified on label

[1]Since the maximum application rate is equal to the maximum seasonal rate, the maximum number of applications is assumed to be one.

[2]Non-agricultural uses including: grounds/landscape maintenance; ornamental production; commercial/ industrial/ recreational lawns; ornamental nurseries; christmas tree plantations; rights-of-way/fencerows/hedgerows; around paved areas; around commercial, industrial, institutional buildings.

Of all of the registered uses of pendimethalin (excluding non-CA Special Local Needs [SLN] registrations), the following uses are excluded from our assessment because they are not registered for use in or applicable to CA:

- peanuts (not grown in CA)
- tobacco (not grown in CA).

Several pendimethalin crops can be grown more than one time per year in CA (i.e., they have multiple crop cycles). Most pendimethalin product labels specify application rates on a per crop cycle basis (not on a per year basis). Information from BEAD indicates that many crops can be grown more than one time/year in California (U.S. EPA 2007). For the labeled application rates and information from EPA's Office of Pesticide Programs' Benefits and Economic Analysis Division (BEAD) on the number of times each crop for which pendimethalin is registered for use can be grown in CA see **APPENDIX B**.

BEAD provided agricultural information by state in its Pendimethalin Chemical Profile for Registration Review (USEPA 2012). The BEAD report states: "The states with the most agricultural usage in terms of pounds AI applied are California (19%), Texas (8%), Georgia (8%), Iowa (6%), Illinois (5%), and Louisiana (5%). In terms of total area treated the top states are Texas (11%), Georgia (10%), California (9%), Iowa (7%) and Illinois (5%)."
Figure 2-1 shows the 2006-2010 estimated annual agricultural use of pendimethalin from the BEAD report.

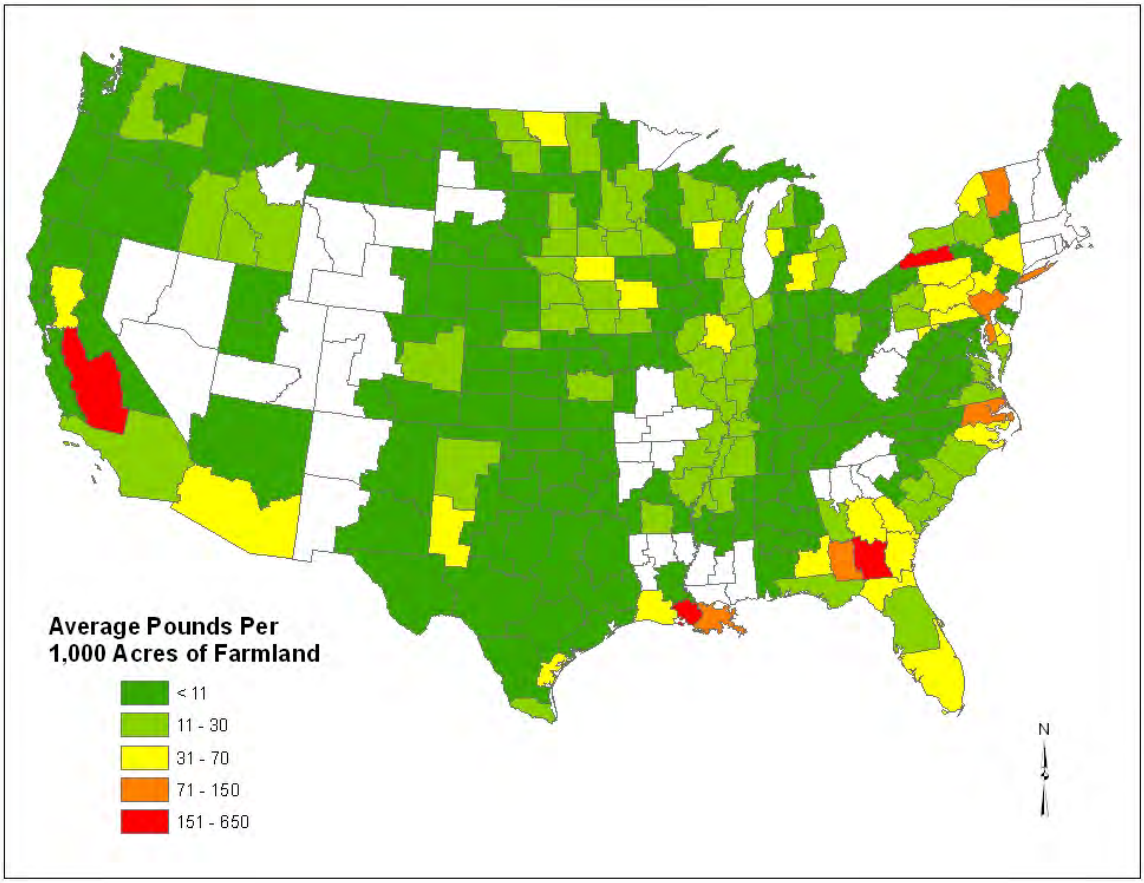

Figure 2-1. Pendimethalin Usage by Crop Reporting District (2006-2010). [1]

BEAD also provides an analysis of both national- and county-level usage information (Memo from Monisha Kaul in BEAD to Rochelle Richardson in EFED dated February 22, 2012) using

[1] This is a map of agricultural pesticide usage at the Crop Reporting District (CRD) level. CRDs are boundaries created by USDA NASS which are aggregates of counties (USDA, 2010). Pesticide usage is displayed as average pounds (for the years 2006-2010) per 1,000 acres offarmland in a CRD to normalize for the variation in farmland between CRDs. Farmland acreage was obtained from USDA (2007). Usage is based on private market surveys of pesticide use in agriculture (Proprietary Data, 2006-2010). The survey data are limited to the states that represent the top 80-90% of acreage for the individual crops, therefore, use may be occurring in regions outside the scope of the survey. CRDs showing no usage of pesticides may be due to either the lack of pesticide use in the region or non-participation in the agricultural surveys. In addition, across the years, there may be variations in the specific crops included in the CRD survey. This may result in a lower annual average for the CRD.
Sources:
Proprietary Data. 2006-2010.
USDA, 2006-2010. NASS Crop Reporting Districts. Online:
http://www.ers.usda.govlbriefing/arms/resourceregions/resourceregions.htm#nass.
USDA,2007. Census of Agriculture. Online: http://www.agcensus.usda.gov/Publications/2007Iindex.asp.

state-level usage data obtained from USDA-NASS[2], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature) and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[3]. CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for pendimethalin by county in this California-specific assessment were generated using CDPR PUR data. Eleven years (1999-2010) of usage data were included in this analysis. Data from CDPR PUR were obtained for every agricultural pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system.[4] BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage involved summarizing across all applications made within a section and then across all sections within a county for each use site and for each pesticide. The county level usage data that were calculated include: average annual pounds applied, average annual area treated, and average and maximum application rate across all eleven years. The units of area treated are also provided where available.

It is important to note that the uses considered in this risk assessment represent all currently registered uses according to a review of all current labels. No other uses are relevant to this assessment. Any reported use, such as may be seen in the CDPR PUR database, represent either historic uses that have been canceled, mis-reported uses, or mis-use. Historical uses, mis-reported uses, and misuse are not considered part of the federal action and, therefore, are not considered in this assessment.

CDPR PUR data for all pendimethalin uses in CA can be found in **Table 2-6**. All uses that were misuses, unknown uses, or uses that have been cancelled are not included in the table below.

Table 2-6. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2010 for Currently Registered Pendimethalin Uses[1]

Site Name	Average Annual Area Treated	Unit Area Treated	Average Application Rate (lbs a.i./A)	MAX Application Rate (lbs a.i./A)
ALFALFA	13.52	Misc. unit	1.8	2.0
ALFALFA	136,671.31	Acres	2.3	75.8
ALMOND	18.74	Misc. unit	1.7	4.1
ALMOND	137,758.50	Acres	2.1	29.6
ANIMAL PREMISE	24.43	Acres	4.7	8.3

[2] United States Depart of Agriculture (USDA), National Agricultural Statistics Service (NASS) Chemical Use Reports provide summary pesticide usage statistics for select agricultural use sites by chemical, crop and state. See http://www.pestmanagement.info/nass/app_usage.cfm.

[3] The California Department of Pesticide Regulation's Pesticide Use Reporting database provides a census of pesticide applications in the state. See http://www.cdpr.ca.gov/docs/pur/purmain.htm.

[4] Most pesticide applications to parks, golf courses, cemeteries, rangeland, pastures, and along roadside and railroad rights of way, and postharvest treatments of agricultural commodities are reported in the database. The primary exceptions to the reporting requirement are home-and-garden use and most industrial and institutional uses (http://www.cdpr.ca.gov/docs/pur/purmain.htm).

ANIMAL PREMISE	0.01	Misc. unit	0.0	0.0
APPLE	217.82	Acres	1.8	5.7
APRICOT	799.61	Acres	2.3	6.2
ARTICHOKE, GLOBE	47.11	Acres	1.1	3.9
ASPARAGUS	87.37	Acres	2.2	3.8
BARLEY	7.29	Acres	2.5	2.5
BEAN, DRIED	7,203.37	Acres	1.0	8.3
BEAN, SUCCULENT	1,502.25	Acres	0.8	4.7
BEAN, UNSPECIFIED	700.82	Acres	1.2	12.5
BROCCOLI	8.16	Acres	0.9	1.3
BUILDINGS/NON-AG OUTDROOR	1.09	Acres	1.4	1.9
CANTALOUPE	5.50	Acres	0.9	0.9
CARROT	6,320.27	Acres	0.9	7.6
CELERY	1.25	Acres	0.6	0.6
CHERRY	5,232.52	Acres	2.3	74.0
CHESTNUT	13.82	Acres	2.4	3.8
CHRISTMAS TREE	21.00	Acres	1.1	4.0
CITRUS	158.50	Acres	2.6	3.8
COMMODITY FUMIGATION	5.64			
CORN (FORAGE - FODDER)	8,578.31	Acres	1.2	12.5
CORN, HUMAN CONSUMPTION	6,787.89	Acres	0.9	13.9
COTTON	126,949.66	Acres	1.0	14.4
COTTON (FORAGE - FODDER)	22.65	Acres	1.0	1.0
ENDIVE (ESCAROLE)	2.78	Acres	0.8	0.8
FIG	64.13	Acres	2.2	3.3
FORAGE HAY/SILAGE	4.86	Acres	1.7	1.7
FOREST, TIMBERLAND	5.53	Acres	1.8	3.3
FOREST, TIMBERLAND	0.01	Misc. unit	0.0	0.0
FUMIGATION, OTHER	0.14			
GARBANZOS	317.55	Acres	1.1	1.4
GARLIC	12,311.67	Acres	0.9	12.6
GRAPE	20,182.67	Acres	2.0	28.4
GRAPE, WINE	32,322.33	Acres	2.2	60.6
GRAPE, WINE	4.17	Square feet	1.3	1.3
GRAPEFRUIT	288.96	Acres	2.9	4.3
INDUSTRIAL SITE	5.21	Acres	2.6	4.7
KIWI	3.33	Acres	2.9	4.2
LANDSCAPE MAINTENANCE	50,053.77			
LANDSCAPE MAINTENANCE	37.40	Acres	2.5	20.1
LANDSCAPE MAINTENANCE	0.25	Misc. unit	0.3	0.3
LEEK	0.68	Acres	1.2	1.4
LEMON	1,464.00	Acres	2.3	5.7
LETTUCE, LEAF	3.30	Acres	1.0	1.0
MELON	1.11	Acres	1.7	3.3
N-GRNHS FLOWER	176.54	Acres	2.1	15.8
N-GRNHS FLOWER	0.00			

N-GRNHS FLOWER	0.43	Square feet	0.0	0.0
N-GRNHS FLOWER	0.46	Tons	0.0	0.0
N-GRNHS PLANTS IN CONTAINERS	18.67	Square feet	0.0	0.0
N-GRNHS PLANTS IN CONTAINERS	99.76	Acres	4.3	133.3
N-GRNHS TRANSPLANTS	0.00			
N-GRNHS TRANSPLANTS	4.53	Acres	1.4	6.0
N-GRNHS TRANSPLANTS	2.30	Square feet	0.0	0.0
N-OUTDR FLOWER	268.96	Acres	1.5	7.0
N-OUTDR FLOWER	0.03	Square feet	0.0	0.0
N-OUTDR PLANTS IN CONTAINERS	7.14			
N-OUTDR PLANTS IN CONTAINERS	6,846.49	Acres	1.7	60.0
N-OUTDR PLANTS IN CONTAINERS	4.45	Misc. unit	0.0	0.5
N-OUTDR PLANTS IN CONTAINERS	90.99	Square feet	0.0	3.3
N-OUTDR TRANSPLANTS	467.09	Acres	1.5	30.9
N-OUTDR TRANSPLANTS	1.70	Misc. unit	1.5	2.0
N-OUTDR TRANSPLANTS	13.46	Square feet	0.0	0.0
NECTARINE	7,101.65	Acres	2.1	94.7
OAT	15.83	Acres	3.3	4.0
OAT (FORAGE - FODDER)	0.63	Acres	4.2	4.2
OKRA	1.56	Acres	0.6	0.6
OLIVE	347.03	Acres	2.0	3.8
ONION, DRY	20,517.97	Acres	0.8	15.9
ONION, GREEN	44.59	Acres	0.9	1.3
ORANGE	26,897.79	Acres	2.9	94.7
PASTURELAND	1.92	Acres	0.4	0.8
PEACH	11,093.62	Acres	2.2	94.7
PEAR	253.00	Acres	2.0	4.0
PEAS	44.64	Acres	1.0	1.4
PECAN	107.56	Acres	1.7	3.8
PEPPER, FRUITING	380.35	Acres	0.9	1.5
PEPPER, SPICE	1.31	Acres	0.7	0.7
PISTACHIO	58,127.06	Acres	2.5	21.6
PLUM	6,181.01	Acres	2.3	31.6
POMEGRANATE	7,384.80	Acres	3.0	7.6
POTATO	8,043.29	Acres	0.7	7.1
PRUNE	5,404.52	Acres	2.3	15.2
PUBLIC HEALTH	22.63			
RANGELAND	12.52	Acres	2.2	4.0
REGULATORY PEST CONTROL	5.26			
REGULATORY PEST CONTROL	13.73	Acres	1.5	1.5
RESEARCH COMMODITY	0.55	Acres	1.5	2.0
RESEARCH COMMODITY	12.00			
RICE	5,844.81	Acres	0.9	18.6
RIGHTS OF WAY	89.84	Acres	2.2	5.7
RIGHTS OF WAY	7.89	Misc. unit	3.8	3.8
RIGHTS OF WAY	48,970.51			

SAFFLOWER	321.09	Acres	1.3	1.5
SHALLOT	8.71	Acres	1.3	1.4
SOIL FUMIGATION/PREPLANT	1,844.49	Acres	1.3	12.0
SOIL FUMIGATION/PREPLANT	0.00	Square feet		
SORGHUM (FORAGE - FODDER)	192.80	Acres	0.9	1.9
SORGHUM/MILO	652.27	Acres	1.0	1.4
SPINACH	0.94	Acres	0.4	0.4
SQUASH	1.09	Acres	0.6	0.6
STRAWBERRY	121.06	Acres	0.9	1.4
STRUCTURAL PEST CONTROL	5.39	Acres	3.4	3.5
STRUCTURAL PEST CONTROL	415.06			
SUDANGRASS	18.50	Acres	1.5	1.5
SUGARBEET	37.69	Acres	1.1	1.2
SUGARCANE	303.92	Acres	2.1	2.9
SUNFLOWER	2,214.40	Acres	1.0	3.8
TANGELO	755.00	Acres	2.9	9.5
TANGERINE	7,305.56	Acres	2.9	47.5
TOMATO	337.58	Acres	0.8	1.4
TOMATO, PROCESSING	9,342.24	Acres	1.0	94.7
TURF/SOD	606.77	Acres	1.0	13.5
TURF/SOD	0.43	Square feet	0.0	0.0
TURF/SOD	0.01	Tons	0.0	0.0
UNCULTIVATED AG	4,288.53	Acres	2.0	26.5
UNCULTIVATED NON-AG	114.77	Acres	2.1	37.9
UNCULTIVATED NON-AG	3.06	Square feet	0.0	0.0
UNKNOWN	86.33	Acres	1.4	1.9
UNKNOWN	0.00			
VEGETABLE	0.24	Acres	1.5	3.6
VERTEBRATE CONTROL	40.86			
WALNUT	22,243.40	Acres	2.3	69.6
WALNUT	10.64	Square feet	4.0	4.0
WALNUT	16.35	Misc. unit	1.6	3.8
WATER (INDUSTRLIAL)	6.14	Acres	0.4	0.7
WATER AREA	20.53	Acres	2.6	3.8
WHEAT	576.92	Acres	1.2	3.8
WHEAT (FORAGE - FODDER)	247.23	Acres	1.3	1.4

[1]Based on data supplied by BEAD (February 22, 2012).

2.5. Assessed Species

Table 2-7 provides a summary of the current distribution, habitat requirements, and life history parameters for the BCB. More detailed life-history and distribution information can be found in Attachment III. See **Figure 2-2** for maps of the current range and designated critical habitat of the BCB.

- **Bay Checkerspot Butterfly (BCB):** The BCB was listed as threatened in 1987 by the USFWS. The species primarily inhabits native grasslands on serpentine outcrops around the San Francisco Bay Area in California.

Table 2-7. Summary of Current Distribution, Habitat Requirements, and Life History Information for the Assessed Listed Species[1]

Assessed Species	Size	Current Range	Habitat Type	Designated Critical Habitat?	Reproductive Cycle	Diet
Bay Checkerspot Butterfly (BCB) (*Euphydryas editha bayensis*)	Adult butterfly - 5 cm in length	Santa Clara and San Mateo Counties [Because the BCB distribution is considered a metapopulation, any site with appropriate habitat in the vicinity of its historic range (Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara counties) should be considered potentially occupied by the butterfly (USFWS 1998, p. II-177)].	1) Primary habitat – native grasslands on large serpentine outcrops; 2) Secondary habitat – 'islands' of smaller serpentine outcrops with native grassland; 3) Tertiary habitat – non-serpentine areas where larval food plants occur	Yes	Larvae hatch in March – May and grow to the 4th instar in about two weeks. The larvae enter into a period of dormancy (diapause) that lasts through the summer. The larvae resume activity with the start of the rainy season. Larvae pupate once they reach a weight of 300 - 500 milligrams. Adults emerge within 15 to 30 days depending on thermal conditions, feed on nectar, mate and lay eggs during a flight season that lasts 4 to 6 weeks from late February to early May	Obligate with dwarf plantain. Primary diet is dwarf plantain plants (may also feed on purple owl's-clover or exserted paintbrush if the dwarf plantains senesce before the larvae pupate). Adults feed on the nectar of a variety of plants found in association with serpentine grasslands

[1] For more detailed information on the distribution, habitat requirements, and life history information of the assessed listed species, see Attachment II.

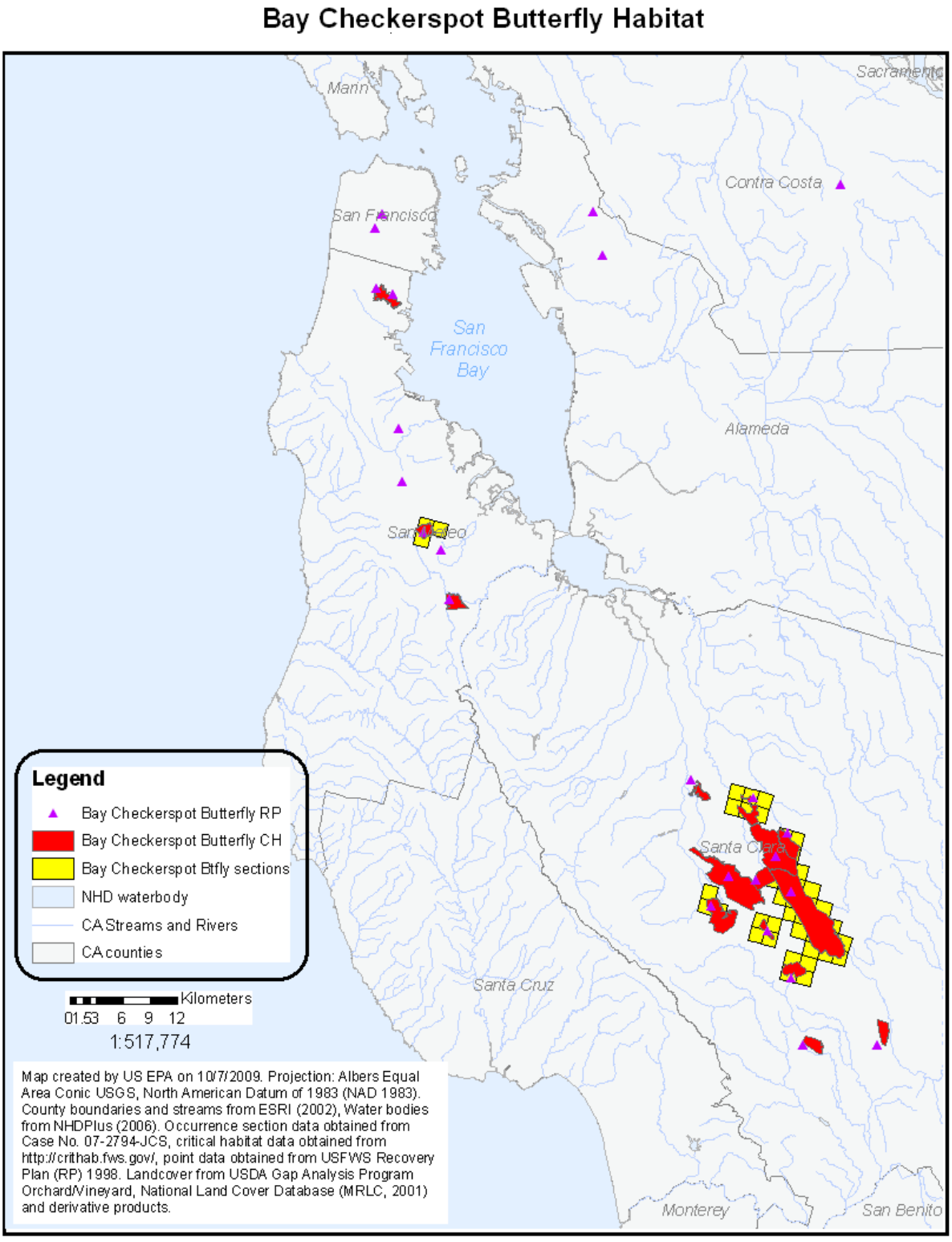

Figure 2-2. Bay Checkerspot Butterfly (BCB) (*Euphydryas editha bayensis*) Critical Habitat and Occurrence Sections identified in Case No. 07-2794-JCS

2.6. Designated Critical Habitat

Critical habitat has been designated for the BCB. Risk to critical habitat is evaluated separately from risk to effects on the species. 'Critical habitat' is defined in the ESA as the geographic area occupied by the species at the time of the listing where the physical and biological features necessary for the conservation of the species exist, and there is a need for special management to protect the listed species. It may also include areas outside the occupied area at the time of listing if such areas are 'essential to the conservation of the species. Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species or areas that contain certain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)). **Table 2-8** describes the PCEs for the critical habitats designated for the BCB.

Table 2-8. Designated Critical Habitat PCEs for the BCB Species[1].

Species	PCEs	Reference
Bay Checkerspot Butterfly	The presence of annual or perennial grasslands with little to no overstory that provide north/south and east/west slopes with a tilt of more than 7 degrees for larval host plant survival during periods of atypical weather (*e.g*., drought).	66 FR 21449 21489, 2001
	The presence of the primary larval host plant, dwarf plantain (*Plantago erecta*) (a dicot) and at least one of the secondary host plants, purple owl's-clover or exserted paintbrush, are required for reproduction, feeding, and larval development.	
	The presence of adult nectar sources for feeding.	
	Aquatic features such as wetlands, springs, seeps, streams, lakes, and ponds and their associated banks, that provide moisture during periods of spring drought; these features can be ephemeral, seasonal, or permanent.	
	Soils derived from serpentinite ultramafic rock (Montara, Climara, Henneke, Hentine, and Obispo soil series) or similar soils (Inks, Candlestick, Los Gatos, Fagan, and Barnabe soil series) that provide areas with fewer aggressive, nonnative plant species for larval host plant and adult nectar plant survival and reproduction.[2]	
	The presence of stable holes and cracks in the soil, and surface rock outcrops that provide shelter for the larval stage of the bay checkerspot butterfly during summer diapause.[2]	

[1] These PCEs are in addition to more general requirements for habitat areas that provide essential life cycle needs of the species such as, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

[2] PCEs that are abiotic, including, physical-chemical water quality parameters such as salinity, pH, and hardness are not evaluated.

More detail on the designated critical habitat applicable to this assessment can be found in Attachment II. Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions

related to use of pendimethalin that may alter the PCEs of the designated critical habitat for BCB, form the basis of the critical habitat impact analysis.

As previously noted in Section 2.1, the Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because pendimethalin is expected to directly impact living organisms within the action area, critical habitat analysis for pendimethalin is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes.

2.7. Action Area and LAA Effects Determination Area

2.7.1. Action Area

The action area is used to identify areas that could be affected by the Federal action. The Federal action is the authorization or registration of pesticide use or uses as described on the label(s) of pesticide products containing a particular active ingredient. The action area is defined by the Endangered Species Act as, "all areas to be affected directly or indirectly by the Federal action and not merely the immediate are involved in the action" (50 CFR §402.2). Based on an analysis of the Federal action, the action area is defined by the actual and potential use of the pesticide and areas where that use could result in effects. Specific measures of ecological effect for the assessed species that define the action area include any direct and indirect toxic effect to the assessed species and any potential modification of its critical habitat, including reduction in survival, growth, and fecundity as well as the full suite of sublethal effects available in the effects literature. It is recognized that the overall action area for the national registration of pendimethalin is likely to encompass considerable portions of the United States based on the large array of agricultural and non-agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the BCB and its designated critical habitat within the state of California. For this assessment, the entire state of California is considered the action area. The purpose of defining the action area as the entire state of California is to ensure that the initial area of consideration encompasses all areas where the pesticide may be used now and in the future, including the potential for off-site transport via spray drift that could influence the San Francisco Bay Species. Additionally, the concept of a state-wide action area takes into account the potential for direct and indirect effects and any potential modification to critical habitat based on ecological effect measures associated with reduction in survival, growth, and reproduction, as well as the full suite of sublethal effects available in the effects literature.

It is important to note that the state-wide action area does not imply that direct and/or indirect effects and/or critical habitat modification are expected to or are likely to occur over the full extent of the action area, but rather to identify all areas that may potentially be affected by the action. The Agency uses more rigorous analysis including consideration of available land cover data, toxicity data, and exposure information to determine areas where BCB and its designated critical habitat may be affected or modified via endpoints associated with reduced survival, growth, or reproduction.

2.7.2. LAA Effects Determination Area

A stepwise approach is used to define the Likely to Adversely Affect (LAA) Effects Determination Area. An LAA effects determination applies to those areas where it is expected that the pesticide's use will directly or indirectly affect the species and/or modify its designated critical habitat using EFED's standard assessment procedures (see Attachment I) and effects endpoints related to survival, growth, and reproduction. This is the area where the "Potential Area of LAA Effects" (initial area of concern + drift distance or downstream dilution distance) overlaps with the range and/or designated critical habitat for the species being assessed. If there is no overlap between the potential area of LAA effects and the habitat or occurrence areas, a no effect determination is made. The first step in defining the LAA Effects Determination Area is to understand the federal action. The federal action is defined by the currently labeled uses for pendimethalin. An analysis of labeled uses and review of available product labels was completed. Labeled uses that are special local needs (SLN) uses not specified for use in California or are restricted to specific states and are excluded from this assessment. In addition, a distinction has been made between food use crops and those that are non-food/non-agricultural uses. For those uses relevant to the assessed species, the analysis indicates that, for pendimethalin, there is a multitude of agricultural, orchard, and non-agricultural uses that are considered as part of the federal action evaluated in this assessment. For a summary of uses, please see **Table 2-6**.

Following a determination of the assessed uses, an evaluation of the potential "footprint" of pendimethalin use patterns (*i.e.*, the area where pesticide application may occur) is determined. This "footprint" represents the initial area of concern, based on an analysis of available land cover data for the state of California. The initial area of concern is defined as all land cover types and the stream reaches within the land cover areas that represent the labeled uses described above. For pendimethalin, these land cover types include cultivated crops; developed high, low, medium intensity; developed open space; forest; open water; orchards; pasture/hay; and wetlands. Since there are a large number of uses covering a high number of land cover types, in this case, an initial area of concern map is not necessary. Since the chemical may be used over a wide area, an initial area of concern map may under represent potential use.

Once the initial area of concern is defined, the next step is to define the potential boundaries of the Potential Area of LAA Effects by determining the extent of offsite transport via spray drift and runoff where exposure of one or more taxonomic groups to the pesticide will result in exceedances of the listed species LOCs.

The AgDRIFT model (Version 2.01) is used to define how far from the initial area of concern an effect to a given species may be expected via spray drift (*e.g.*, the drift distance). The spray drift analysis for pendimethalin uses the most sensitive endpoint for terrestrial exposure. The terrestrial exposure spray drift analysis was further broken down into invertebrates versus plants. The most sensitive endpoints looked at for spray drift were: 47.9 µg a.i./bee (acute invertebrate, terrestrial assessment), 0.0008 lb a.i./A (plant, terrestrial assessment). Further details on the spray drift analysis are provided in Section 5.2.4.a.

An evaluation of usage information was conducted to determine the area where use of pendimethalin may impact the assessed species. This analysis is used to characterize where predicted exposures are most likely to occur, but does not preclude use in other portions of the action area. A more detailed review of the county-level use information was also completed. These data suggest that pendimethalin has historically been used on a wide variety of agricultural and non-agricultural uses.

2.8. Assessment Endpoints and Measures of Ecological Effect

For more information on the assessment endpoints, measures of ecological effect, see Attachment I.

2.8.1. Assessment Endpoints

A complete discussion of all the toxicity data available for this risk assessment, including resulting measures of ecological effect selected for each taxonomic group of concern, is included in Section 4 of this document. **Table 2-9** identifies the taxa used to assess the potential for direct and indirect effects from the uses of pendimethalin for each listed species assessed here. The specific assessment endpoints used to assess the potential for direct and indirect effects to each listed species are provided in **Table 2-10**.

Table 2-9. Taxa Used in the Analyses of Direct and Indirect Effects for the Assessed Listed Species.

Listed Species	Birds	Mammals	Terr. Plants	Terr. Inverts.	FW Fish	FW Inverts.	Estuarine /Marine Fish	Estuarine /Marine Inverts.	Aquatic Plants
Bay checkerspot butterfly	n/a	n/a	Indirect (food/ habitat)* No data available	Direct Acute only: Honey bee	n/a	n/a	n/a	n/a	n/a

Abbreviations: n/a = Not applicable; Terr. = Terrestrial; Invert. = Invertebrate; FW = Freshwater
* obligate relationship

Table 2-10. Taxa and Assessment Endpoints Used to Evaluate the Potential for Use of Pendimethalin to Result in Direct and Indirect Effects to the Assessed Listed Species or Modification of Critical Habitat.

Taxa Used to Assess Direct and Indirect Effects to Assessed Species and/or Modification to Critical Habitat or Habitat	Assessed Listed Species	Assessment Endpoints	Measures of Ecological Effects
1. Terrestrial Invertebrates	Direct Effect -Bay Checkerspot Butterfly	Survival, growth, and reproduction of individuals via direct effects	1a. Most sensitive terrestrial invertebrate acute contact LD_{50} (>49.7 µg a.i./bee) for the honey bee (*Apis mellifera*, MRID 0009980); 1b. Most sensitive terrestrial invertebrate chronic NOAEC (guideline or ECOTOX)
	Indirect Effect (prey) -None		

Taxa Used to Assess Direct and Indirect Effects to Assessed Species and/or Modification to Critical Habitat or Habitat	Assessed Listed Species	Assessment Endpoints	Measures of Ecological Effects
			1c. Chronic toxicity studies are not available so risk cannot be precluded
2. Terrestrial Plants	Indirect Effect (food/habitat) (non-obligate relationship) -None Indirect Effect (food/habitat) (obligate relationship) -Bay Checkerspot Butterfly	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat (BCB) via indirect effects on food and habitat (*i.e.*, riparian and upland vegetation)	2a. Distribution of EC_{25} (EC_{05} or NOAEC) for monocots (seedling emergence, vegetative vigor, or ECOTOX) 2b. Distribution of EC_{25} (EC_{05} or NOAEC) for dicots (seedling emergence, vegetative vigor, or ECOTOX)

Abbreviations: SF=San Francisco

2.8.2. Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of pendimethalin that may alter the PCEs of the assessed species' designated critical habitat. PCEs for the assessed species were previously described in Section 2.6. Actions that may modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the assessed species. Therefore, these actions are identified as assessment endpoints. It should be noted that evaluation of PCEs as assessment endpoints is limited to those of a biological nature (*i.e.*, the biological resource requirements for the listed species associated with the critical habitat) and those for which pendimethalin effects data are available.

Assessment endpoints used to evaluate potential for direct and indirect effects are equivalent to the assessment endpoints used to evaluate potential effects to designated critical habitat. If a potential for direct or indirect effects is found, then there is also a potential for effects to critical habitat. Some components of these PCEs are associated with physical abiotic features (*e.g.*, presence and/or depth of a water body, or distance between two sites), which are not expected to be measurably altered by use of pesticides.

2.9. Conceptual Model

2.9.1. Risk Hypotheses

Risk hypotheses are specific assumptions about potential adverse effects (*i.e.*, changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (USEPA, 1998). For this assessment, the risk is stressor-linked, where the stressor is the release of pendiemthalin to the environment. The following risk hypotheses are presumed in this assessment:

The labeled use of pendimethalin within the action area may:

- directly affect BCB by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect BCB and/or modify their designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect BCB and/or modify their designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range;

2.9.2. Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the pendimethalin release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for BCB species and the conceptual models for the terrestrial PCE components of critical habitat are shown in **Figure 2-4**. Although the conceptual models for direct/indirect effects and modification of designated critical habitat PCEs are shown on the same diagrams, the potential for direct/indirect effects and modification of PCEs will be evaluated separately in this assessment. Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure routes to potential risks to BCB and modification to designated critical habitat is expected to be negligible.

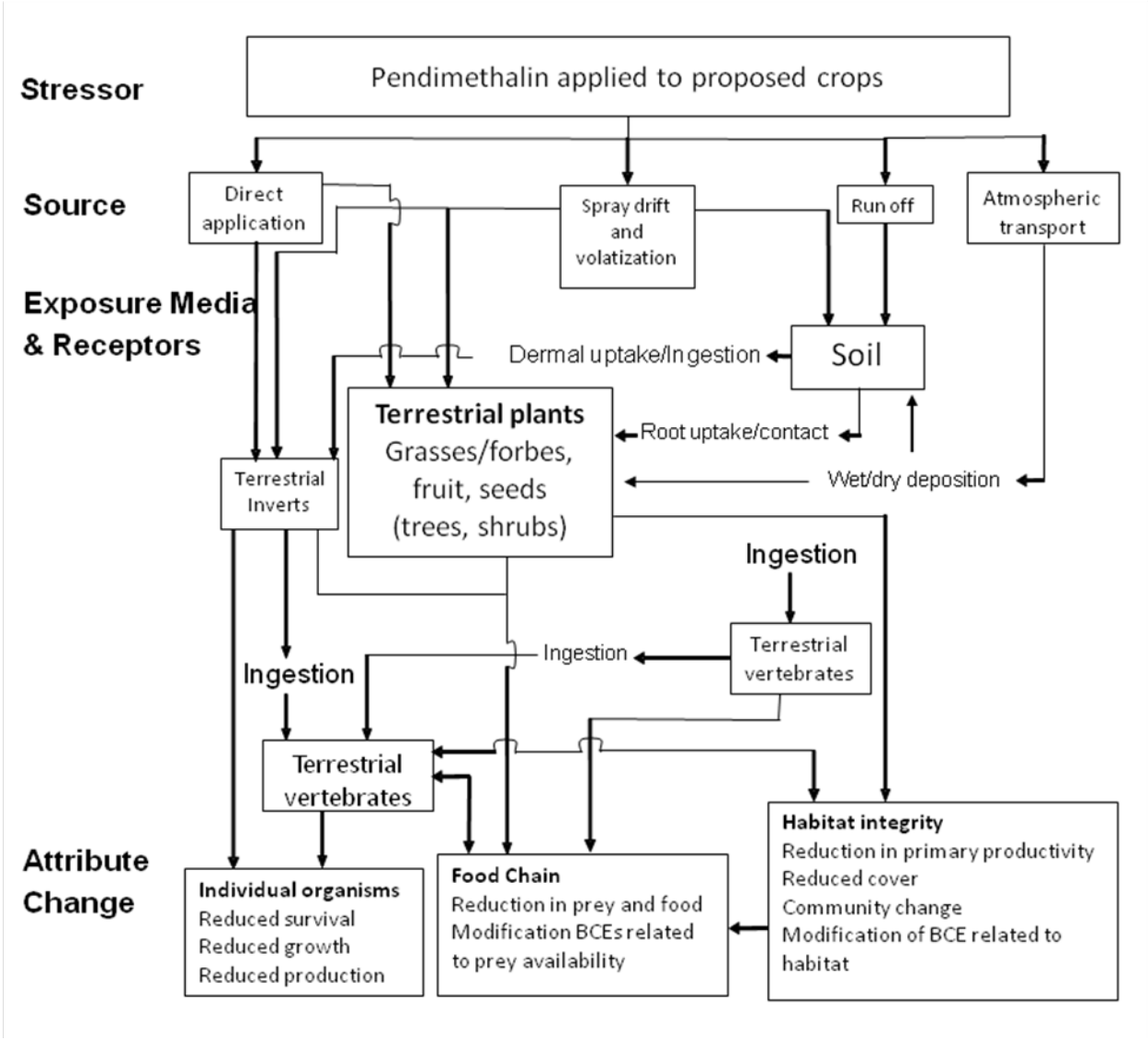

Figure 2-4. Conceptual model depicting stressors, exposure pathways, and potential effects to terrestrial organisms from the use of pendimethalin.

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2.10. Analysis Plan

In order to address the risk hypothesis, the potential for direct and indirect effects to the assessed species, prey items, and habitat is estimated based on a taxon-level approach. In the following sections, the use, environmental fate, and ecological effects of pendimethalin are characterized and integrated to assess the risks. This is accomplished using a risk quotient (ratio of exposure concentration to effects concentration) approach. Although risk is often defined as the likelihood and magnitude of adverse ecological effects, the risk quotient-based approach does not provide a quantitative estimate of likelihood and/or magnitude of an adverse effect. However, as outlined in the Overview Document (USEPA, 2004), the likelihood of effects to individual organisms

from particular uses of pendimethalin is estimated using the probit dose-response slope and either the level of concern (discussed below) or actual calculated risk quotient value.

Descriptions of routine procedures for evaluating risk to the San Francisco Bay Species are provided in Attachment I.

2.10.1. Measures of Exposure

The environmental fate properties of pendimethalin along with available monitoring data indicate that runoff (for terrestrial plants) and spray drift (for terrestrial plants and invertebrates) are the principle potential transport mechanisms of pendimethalin to terrestrial habitats.

Measures of exposure are based on terrestrial models that predict estimated environmental concentrations (EECs) of pendimethalin using maximum labeled application rates and methods of application. The model used to predict terrestrial EECs on food items is Terrestrial Residue Exposure (T-REX) model. The model used to derive EECs relevant to terrestrial and wetland plants is TerrPlant. These models are parameterized using relevant reviewed registrant-submitted environmental fate data. More information on these models is available in Attachment I.

2.10.1.a. Estimating Exposure in the Terrestrial Environment

For the foliar uses, the terrestrial measure of exposure for invertebrate animals is based on the upper bound concentration of residues normalized for application rates on various dietary items.

2.10.2. Measures of Effect

Data identified in Section 2.8 are used as measures of effect for direct and indirect effects. Data were obtained from registrant submitted studies or from literature studies identified by ECOTOX. More information on the ECOTOXicology (ECOTOX) database and how toxicological data is used in assessments is available in Attachment I.

2.10.3. Integration of Exposure and Effects

Risk characterization is the integration of exposure and ecological effects characterization to determine the potential ecological risk from agricultural and non-agricultural uses of pendimethalin, and the likelihood of direct and indirect effects to the assessed species in terrestrial habitats. The exposure and toxicity effects data are integrated in order to evaluate the risks of adverse ecological effects on non-target species. The risk quotient (RQ) method is used to compare exposure and measured toxicity values. EECs are divided by acute and chronic toxicity values. The resulting RQs are then compared to the Agency's levels of concern (LOCs) (USEPA, 2004) (see **Appendix C**). More information on standard assessment procedures is available in Attachment I.

2.10.4. Data Gaps

All terrestrial plant testing was conducted with the active ingredient (TGAI – technical grade active ingredient) and did not include solvent controls. The use of TEP (typical end-use product) instead of TGAI is recommended for all terrestrial non-target plant studies. Testing with only the TGAI may underestimate toxicity to plants because the TEP may include a solvent or adjuvant which results in additive or synergistic toxicity.

The honeybee contact toxicity data is used as a surrogate assessment endpoint for all terrestrial invertebrates, including the BCB. However, no mortalities were observed at the highest treatment dose (49.8 µg a.i./bee) from the available acute honeybee study and the magnitude of risk cannot be determined. This may result in an overestimation of risk for the BCB. Additionally, chronic toxicity data for the honeybee, or other terrestrial invertebrates, are not available. Without this information risks to growth and fecundity cannot be precluded for the BCB.

No foliar dissipation studies were supplied by the registrant. Therefore, the default assumption foliar half-life of 35 days was used to calculate pendimethalin residue concentrations on terrestrial invertebrates and terrestrial food items. Pendimethalin is a persistent compound in some environments. Laboratory field dissipation studies in soil under aerobic conditions demonstrate a half-life of approximately 72-172 days, and field dissipation studies in the Midwest similarly show half-lives ranging from 84-147 days. If the foliar dissipation half-life is similar to or greater than the available soil half-life data, the default assumption of a 35-day half-life may underestimate exposure to terrestrial mammals and birds.

3. Exposure Assessment

Pendimethalin is applied as a liquid spray formulation. Pendimethalin can be applied either by aerial or ground equipment to a variety of agricultural and non-agricultural sites. It can be broadcasted by air or ground, and be banded as a directed spray or applied by irrigation equipment in various crops. It can also be left on the soil surface or incorporated. Although all potential uses are assessed, risks from ground boom and aerial applications are focused on in this assessment because they are expected to result in the highest off-target concentrations of pendimethalin.

3.1. Label Application Rates and Intervals

Pendimethalin labels may be categorized into two types: labels for manufacturing uses (including technical grade pendimethalin and its formulated products) and end-use products. While technical products, which contain pendimethalin of high purity, are not used directly in the environment, they are used to make formulated products, which can be applied in specific areas to control weeds. The formulated product labels legally limit pendimethalin's potential use to only those sites that are specified on the labels.

In addition, the following labeling statements appear on all pendimethalin labels to avoid contamination of endangered plant species from use on agricultural products. There are no labeling statements to avoid contact of pendimethalin with terrestrial invertebrates or endangered species other than plants.

ENDANGERED SPECIES PROTECTION

- If endangered plant species occur in proximity to the application sites, the following mitigations are required:
    - If applied by ground, leave an untreated buffer zone of 200 feet. The product must be applied using low boom (20 inches above the ground) and ASAE fine to medium/coarse nozzles.
    - If applied by air, leave an untreated buffer zone of 170 feet. Must use straight-stream nozzles (D-6 or larger): wind can be no more than 8 mph, and release height must be 15 feet or less.

Currently registered agricultural and non-agricultural uses of pendimethalin within California include a multitude of agricultural and non-agricultural uses. Please see Section 2.4.3 for a full list of uses. The uses being assessed are summarized in **Table 2-5**. The uses modeled below encompass the range of uses; the highest, median, and lowest application rates; and the uses where pendimethalin is applied the most based on information provided by BEAD.

3.2. Terrestrial Animal Exposure Assessment

3.2.1. Exposure to Residues in Terrestrial Food Items

T-REX (Version 1.5.1) is used to calculate dietary and dose-based EECs of pendimethalin for terrestrial invertebrates. T-REX simulates a 1-year time period. For this assessment, spray applications of pendimethalin are considered. Terrestrial EECs were derived for the uses previously summarized in **Table 2-5**. Exposure estimates generated using T-REX are for the parent alone.

Terrestrial EECs for foliar formulations of pendimethalin were derived for the uses summarized in **Table 2-5**. The default foliar dissipation half-life of 35 days is used based on the T-REX user guide. Use specific input values, including number of applications, application rate, foliar half-life and application interval are provided in **Table 3-1**. For those uses with multiple applications per year (*i.e.*, strawberries and onions), the number of applications were estimated based on the max single application rate and the max annual application rate. An example output from T-REX is available in **Appendix D**.

Table 3-1. Input Parameters for Foliar Applications Used to Derive Terrestrial EECs for Pendimethalin with T-REX

Use (Application method)	Max. Single App. Rate (lbs a.i./A)	Number of Applications per Year*	Application Interval (days)	Max. Annual App. Rate (lbs a.i./A)	Foliar Dissipation Half-Life
Citrus; Nut crops; Grapes	6.00	1	30	6.00	35 days
Pome fruits; Sugarcane	4.00	1	n/s	6.00	35 days
Stone fruits; Leafy and	4.00	1	n/s	4.00	35 days

stem vegetables; Forage grasses; Various non-agricultural uses[1]					
Uncultivated agricultural areas (fallow land); Turfgrass (golf course, non-residential, commercial)	3.00	1	n/s	3.00	35 days
Corn; Cotton; Soybeans; Residential turfgrass; Sod farms	2.00	1	n/s	2.00	35 days
Fruiting vegetables; Root crop vegetables; Legumes; Grain crops; Sunflowers;	1.50	1	n/s	1.50	35 days
Rice; brassica head and stem vegetables, brassica leafy greens	1.00	1	n/s	n/s	35 days
n/s = Not specified in label [1]Non-agricultural uses including: grounds/landscape maintenance; ornamental production; commercial/ industrial/ recreational lawns; ornamental nurseries; christmas tree plantations; rights-of-way/fencerows/hedgerows; around paved areas; around commercial, industrial, institutional buildings. *Number of applications per year was estimated based on max single application rate and max annual application rate.					

3.2.2. Exposure to Terrestrial Invertebrates Derived Using T-REX

T-REX is also used to calculate EECs for terrestrial invertebrates exposed to pendiemthalin from foliar uses. Available acute contact toxicity data for bees exposed to pendiemthalin (in units of µg a.i./bee), are converted to µg a.i./g (of bee) by multiplying 1 bee by 0.128 g (the average weight on an adult honey bee). In this case, the acute contact LD_{50} is >49.7µg a.i./bee for the honey bee (*Apis mellifera*, MRID 0009980), which results in an adjusted toxicity value of >388 µg a.i./g of bee. Dietary-based EECs calculated by T-REX for arthropods (units of µg a.i./g of bee) are used to estimate exposure to terrestrial invertebrates. The EECs are compared to the adjusted acute contact toxicity data for bees in order to derive RQs (**Table 3-2**).

The exposure values are applicable to direct effects to the BCB. An example output from T-REX v. 1.5.1 is available in **Appendix D**.

Table 3-2. Summary EECs Used for Estimating Risk to Terrestrial Invertebrates and Derived Using T-REX ver. 1.5.1 for Pendimethalin

Use, Method of Application[a]	Application Rate (lbs a.i./acre), # of applications	Arthropod EEC (in µg a.i./g of bee, or ppm)
Citrus; Nut crops; Grapes	6.00, 1	564
Pome fruits, Sugarcane; Stone fruits; Leafy and stem vegetables; Forage grasses; Various non-agricultural uses[b]	4.00, 1	376
Uncultivated agricultural areas (fallow land); Turfgrass (golf course, non-residential, commercial)	3.00, 1	282
Corn; Cotton; Soybeans; Residential turfgrass; Sod farms	2.00, 1	188

Fruiting vegetables; Root crop vegetables; Legumes; Grain crops; Sunflowers	1.50, 1	141
Rice; brassica head and stem vegetables, brassica leafy greens	1.00, 1	94
[a] See Table 3-4 for details on the uses. [b]Non-agricultural uses including: grounds/landscape maintenance; ornamental production; commercial/ industrial/ recreational lawns; ornamental nurseries; christmas tree plantations; rights-of-way/fencerows/hedgerows; around paved areas; around commercial, industrial, institutional buildings.		

3.3. Terrestrial Plant Exposure Assessment

TerrPlant (Version 1.2.2) is used to calculate EECs for non-target plant species inhabiting dry and semi-aquatic areas. The model generates EECs for plants residing near a use area that may be exposed via runoff and/or spray drift. The EECs are generated from one application at the maximum rate for a particular use and compound-specific solubility information. Only a single application is considered because it is assumed that for plants, toxic effects are likely to manifest shortly after the initial exposure and that subsequent exposures do not contribute to the response. Hence, the model estimates EECs based on application rate, the solubility factor, and default assumptions of drift. Two different exposure scenarios are considered: ground and aerial applications.

The EECs for terrestrial and semi-aquatic plants for a single application of pendimethalin at the maximum label rate for the pendimethalin uses are presented in **Tables 3-3 and 3-4**. An example output from the TerrPlant model is provided in **Appendix E**.

Table 3-3. EECs for Terrestrial and Semi-Aquatic Plants Near Pendimethalin Use Areas-Ground Sprays.

Use	Single Max. Application Rate (lbs a.i./A)	EECs (lbs a.i./A) (Ground Spray)		
		Total Loading to Adjacent Areas (sheet runoff + drift)	Total Loading to Semi-Aquatic Areas (channelized runoff + drift)	Drift EEC
Citrus; Nut crops; Grapes	6.00	0.12	0.66	0.06
Pome fruits; Sugarcane; Stone fruits; Leafy and stem vegetables; Forage grasses; Various non-agricultural uses[1]	4.00	0.08	0.44	0.04
Uncultivated agricultural areas (fallow land); Turfgrass (golf course, non-residential, commercial)	3.00	0.06	0.33	0.03
Corn; Cotton; Soybeans; Residential turfgrass; Sod farms	2.00	0.04	0.22	0.02
Fruiting vegetables; Root crop vegetables; Legumes; Grain crops; Sunflowers	1.50	0.03	0.165	0.015
Rice; brassica head and stem vegetables, brassica leafy greens	1.00	0.02	0.11	0.01

[1]Non-agricultural uses including: grounds/landscape maintenance; ornamental production; commercial/ industrial/ recreational lawns; ornamental nurseries; christmas tree plantations; rights-of-way/fencerows/hedgerows; around paved areas; around commercial, industrial, institutional buildings.

Table 3-4. EECs for Terrestrial and Semi-Aquatic Plants Near Pendimethalin Use Areas-Aerial Sprays.

Use	Single Max. Application Rate (lbs a.i./A)	EECs (lbs a.i./A) (Aerial Spray)		
		Total Loading to Adjacent Areas (sheet runoff + drift)	Total Loading to Semi-Aquatic Areas (channelized runoff + drift)	Drift EEC
Citrus; Nut crops; Grapes	6.00	0.36	0.90	0.30
Pome fruits; Sugarcane; Stone fruits; Leafy and stem vegetables; Forage grasses; Various non-agricultural uses[1]	4.00	0.24	0.60	0.20
Uncultivated agricultural areas (fallow land); Turfgrass (golf course, non-residential, commercial)	3.00	0.18	0.45	0.15
Corn; Cotton; Soybeans; Residential turfgrass; Sod farms	2.00	0.12	0.30	0.10
Fruiting vegetables; Root crop vegetables; Legumes; Grain crops; Sunflowers	1.50	0.09	0.225	0.075
Rice; brassica head and stem vegetables, brassica leafy greens	1.00	0.06	0.15	0.05

[1]Non-agricultural uses including: grounds/landscape maintenance; ornamental production; commercial/ industrial/ recreational lawns; ornamental nurseries; christmas tree plantations; rights-of-way/fencerows/hedgerows; around paved areas; around commercial, industrial, institutional buildings.

4. Effects Assessment

This assessment evaluates the potential for pendimethalin to directly or indirectly affect BCB or modify its designated critical habitat. Assessment endpoints for the effects determination for each assessed species include direct toxic effects on the survival, reproduction, and growth, as well as indirect effects, such as reduction of the prey base or modification of its habitat. In addition, potential modification of critical habitat is assessed by evaluating effects to the PCEs, which are components of the critical habitat areas that provide essential life cycle needs of each assessed species.

As described in the Agency's Overview Document (USEPA, 2004), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment, evaluated taxa include terrestrial invertebrates and plants.

4.1. Ecotoxicity Study Data Sources

Toxicity endpoints are established based on data generated from guideline studies submitted by the registrant, and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD) (USEPA,

2004). Open literature data presented in this assessment were obtained from ECOTOX information originally compiled Oct. 13, 2004 and refreshed Jan. 2010. In order to be included in the ECOTOX database, papers must meet the following minimum criteria:

(1) the toxic effects are related to single chemical exposure;
(2) the toxic effects are on an aquatic or terrestrial plant or animal species;
(3) there is a biological effect on live, whole organisms;
(4) a concurrent environmental chemical concentration/dose or application rate is reported; and
(5) there is an explicit duration of exposure.

For the purposes of this assessment, 'target' plant species are defined as all agriculatural weed species which are included in the ECOTOX data presented in **Appendix G**. Open literature toxicity data for other 'target' plant species, which include efficacy studies, are not currently considered in deriving the most sensitive endpoint for terrestrial plants. Efficacy studies do not typically provide endpoint values that are useful for risk assessment (*e.g.*, NOAEC, EC_{50}, *etc.*), but rather are intended to identify a dose that maximizes a particular effect (*e.g.*, EC_{100}). Therefore, efficacy data and non-efficacy toxicological target plant data are not included in the ECOTOX open literature summary table provided in **Appendix G.**

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature that are more conservative than the registrant-submitted data are considered. The degree to which open literature data are quantitatively or qualitatively characterized for the effects determination is dependent on whether the information is relevant to the assessment endpoints (*i.e.*, survival, reproduction, and growth) identified in Section 2.8. For example, endpoints such as behavior modifications are likely to be qualitatively evaluated, because quantitative relationships between modifications and reduction in species survival, reproduction, and/or growth are not available. Although the effects determination relies on endpoints that are relevant to the assessment endpoints of survival, growth, or reproduction, it is important to note that the full suite of sublethal endpoints potentially available in the effects literature (regardless of their significance to the assessment endpoints) are considered, as they are relevant to the understanding of the area with potential effects, as defined for the action area.

Citations of all open literature not considered as part of this assessment because they were either rejected by the ECOTOX screen or accepted by ECOTOX but not used (*e.g.*, the endpoint is less sensitive) are included in **Appendix H. Appendix H** also includes a rationale for rejection of those studies that did not pass the ECOTOX screen and those that were not evaluated as part of this endangered species risk assessment.

In addition to registrant-submitted and open literature toxicity information, other sources of information, including use of the acute probit dose response relationship to establish the probability of an individual effect and reviews of ecological incident data, are considered to further refine the characterization of potential ecological effects associated with exposure to pendimethalin. A summary of the available terrestrial ecotoxicity information and the incident information for pendimethalin are provided in Sections 4.1 through 4.4.

4.2. Toxicity of Pendimethalin to Terrestrial Organisms

Table 4-1 summarizes the most sensitive terrestrial toxicity endpoints relevant to this assessment, based on an evaluation of both the submitted studies and the open literature. A brief summary of submitted data considered relevant to this ecological risk assessment is presented below. Additional information is provided in **Appendix F**.

Only one acute oral bee toxicity study (MRID# 0009980) was submitted to the Agency. This study was authored by Atkins et al (1974) and provides an acute oral LD_{50} of greater than 49.8 µg/bee, with no mortality observed at the highest dose tested.

An acute contact bee toxicity study submitted to the European Union (ETX 99-227) provided an LD_{50} value of 100 µg/bee. This study has not been reviewed by the Agency and it is uncertain whether this value would be acceptable for use in risk assessment.

Table 4-1. Terrestrial Toxicity Profile for Pendimethalin

Species	Taxa Represented	Toxicity Value	MRID #	Classification	Comment
Honey bee (*Apis mellifera*)	Terrestrial invertebrates	Acute oral; LD_{50} > 49.7 µg a.i./bee	0009980	Acceptable	None

n/a: not applicable; ND = not determined; bw = body weight

4.2.1. Toxicity to Terrestrial Plants

Tier II terrestrial plant toxicity testing was conducted with the TGAI, rather than the TEP as required by the non-target plant protection data requirements specified in 40 CFR Part 158.660. Based on the available Tier II seedling emergence and vegetative vigor toxicity data for the TGAI, ryegrass and lettuce appear to be the most sensitive monocot and dicot plants, respectively. However, ryegrass appears to be more sensitive in the vegetative vigor test as compared to the seedling emergence test, and lettuce shows similar sensitivity in both tests. It is important to note that all ten test species showed effects >25% in the seedling emergence test, whereas two of the ten test species (including radish and cucumber, both dicots) showed no effect in the vegetative vigor test at the highest treatment level of 4.0 lbs a.i./A. This study did not test the maximum application rate of 6 lbs a.i./A. In addition, use of the TGAI data may underestimate toxicity to plants as the TEP may include adjuvants or surfactants that increase the toxicity of the parent compound. The most sensitive EC_{25} and NOAEC values for ryegrass and lettuce, based on the available TGAI data, are bolded in **Table 4-2**.

Table 4-2. Summary of Tier II Terrestrial Plant Toxicity Data for Pendimethalin.

Crop	Species	EC_{25} (lbs a.i./A)	NOAEC (lbs a.i./A)	Most sensitive parameter
Seedling Emergence				
Monocots	Oat	1.0	0.25	Plant height
	Ryegrass	**0.02**	**0.01**	**Dry weight**
	Corn	0.68	0.5	Plant height
	Onion	0.08	0.06	Dry weight
Dicots	Soybean	4.7	2.0	Dry weight
	Lettuce	**0.09**	**0.063**	**Dry weight**
	Radish	0.86	0.13	Plant height
	Tomato	0.2	0.13	Dry weight
	Cucumber	2.4	0.25	Plant height
	Cabbage	0.44	0.25	Plant height
Vegetative Vigor				
Monocots	Oat	0.78	0.5	Dry weight
	Ryegrass	**0.034**	**0.0008**	**Dry weight**
	Corn	2.8	2.0	Plant height
	Onion	0.56	0.5	Plant height
Dicots	Soybean	0.27	0.13	Dry weight
	Lettuce	**0.10**	**0.003**	**Dry weight**
	Radish	>4.0	>4.0	No effect
	Tomato	0.5	0.13	Dry weight
	Cucumber	>4.0	>4.0	No effect
	Cabbage	4.8	2.0	Dry weight

4.3. Toxicity of Chemical Mixtures

As previously discussed, the results of this analysis suggest that a mixture of pendimethalin and propanil (Reg. Num. 5905-495) may be more toxic than pendimethalin TGAI by a factor of two (MRID 00143441; in review); however, evidence suggests that this increased toxicity can be attributed to propanil. However, because the active ingredients are not expected to have similar mechanisms of actions, metabolites, or toxicokinetic behavior, it is reasonable to conclude that an assumption of dose-addition would not be appropriate. Therefore, this assessment was conducted based on the toxicity of the single active ingredient of pendimethalin.

4.4. Incident Database Review

Preliminary reviews of the Ecological Incident Information System (EIIS, version 2.1) and the Avian Incident Monitoring System (AIMS)[5] were conducted on April 11, 2012 and again on October 9, 2012. A total of 68 EIIS incidents associated with pendimethalin use (not including those classified as 'unlikely' due to pendimethalin use) have been reported (1 involving terrestrial organisms – birds - 2 involving aquatic organisms – all fish- and 65 terrestrial plants). The reported incidents occurred between 1986 and 2004. The certainty in which these incidents were a result of pendimethalin use was described as highly probable in 1 incident, probable in 14 incidents, and possible in 53 incidents. Twenty-six of the incidents were the result of registered

[5] http://www.abcbirds.org/abcprograms/policy/pesticides/aims/aims/index.cfm

use, three were the result of misuse (accidental); however, it is unknown if the remaining incidents resulted from misuse or registered uses. Details of the terrestrial incidents are described below.

In addition to the incidents recorded in EIIS and AIMS, additional incidents have been reported to the Agency in aggregated incident reports, within the US EPA Office of Pesticide Programs Incident Data System (IDS). Pesticide registrants report certain types of incidents to the Agency as aggregate counts of incidents occurring per product per quarter. Ecological incidents reported in aggregate reports include those categorized as 'minor fish and wildlife' (W-B), 'minor plant' (P-B), and 'other non-target' (ONT) incidents. 'Other non-target' incidents include reports of adverse effects to insects and other terrestrial invertebrates. For pendimethalin, as of October 10, 2012 registrants have reported 4 minor fish and wildlife incidents, 1,035 minor plant incidents, and 3 "other non-target" incidents, all of which occurred between 1999 and 2011. The number of individual organisms affected in these incidents was not specified. Unless additional information on these aggregated incidents becomes available, it is assumed that they are representative of registered uses of pendimethalin.

4.4.1. Terrestrial Incidents

One incident was reported for the American robin and the rock dove in Hutchinson, Kansas (I007495-001) by the State of Kansas Department of Wildlife and Parks in April, 1998. Six American robins and six or seven rock doves were found dead after an application of pendimethalin. Toxicological analysis was not provided; however, the investigating biologist determined the deaths likely occurred due to pendimethalin.

4.4.2. Plant Incidents

Numerous plant incidents have been reported as part of the 6(a)2 reporting requirements after damage was observed in various crop species. Twenty-six incidents for peanut crop damage were reported by Valent. Incidents occurred in in Virginia (incident #s I011838-106, I011838-109, and I011838-107), Oklahoma (incident #s I011838-085, I011838-074, I011838-060, I011838-061, I011838-062, I011838-065, I011838-064, I011838-088, I011838-079, I011838-069, I011838-058, I011838-089, I011838-098, I011838-090, I011838-091, I011838-071, and I011838-073), Georgia (incident #s I011838-011, I011838-111, I011942-002, I011838-035, I011838-014, I011838-047, I011838-041, and I011838-043, I011838-050), and North Carolina (incident # I011838-056). Fifteen soybean incidents were reprted by Dow and DuPont in Mississippi (incident # I010927-004), Michigan (incident #s I010927-006, I010927-008, and I010927-007), Illinois (incident # I014702-053)Kansas (incident # I010927-008), Iowa (incident #s I014702-057, I014702-056, I014702-058, I014702-055, I000663-001 and I015748-046), and Arkansas (incident # I015175-001). Six incidents on corn were reported by Dow in Wisconsin (incident # I010927-005), Pennsylvania (incident # I012366-015), and Iowa (incident # I000663-001). Finally, one incident on cotton was reported by Dow in Tennessee (incident # I015748-018). Toxicological symptoms reported include chlorosis, burn down, stunted growth, reduced

yield. Several of the incidents reported "carry-over" effects from application of pendimethalin in previous crop rotations as the likely cause of the observed damage.

5. Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations. Risk characterization is used to determine the potential for direct and/or indirect effects to BCB or for modification to its designated critical habitat from the use of pendimethalin in CA. The risk characterization provides an estimation (Section 5.1) and a description (Section 5.2) of the likelihood of adverse effects; articulates risk assessment assumptions, limitations, and uncertainties; and synthesizes an overall conclusion regarding the likelihood of adverse effects to the assessed species or their designated critical habitat (*i.e.*, "no effect," "likely to adversely affect," or "may affect, but not likely to adversely affect"). In the risk estimation section, risk quotients are calculated using standard EFED procedures and models. In the risk description section, additional analyses may be conducted to help characterize the potential for risk.

5.1. Risk Estimation

Risk is estimated by calculating the ratio of exposure to toxicity. This ratio is the risk quotient (RQ), which is then compared to pre-established acute and chronic levels of concern (LOCs) for each category evaluated (**Appendix C**). For acute risk to terrestrial invertebrates, the interim LOC is 0.05. The LOC for risk to listed and non-listed plants is 1.0.

Acute risks to terrestrial invertebrates and plants are estimated based on exposures resulting from applications of pendimethalin (**Table 3-2** through **Table 3-4**) and the appropriate toxicity endpoint from **Table 4-1** and **Table 4-2**.

5.1.1. Exposures in the Terrestrial Habitat

5.1.1.a. Terrestrial Invertebrates

In order to assess the risks of pendimethalin to terrestrial invertebrates, the honey bee (acute contact LD_{50} of > 49.7 µg a.i./bee; MRID 00009980) is used as a surrogate for terrestrial invertebrates. The toxicity value for terrestrial invertebrates is calculated by multiplying the lowest available acute contact LD_{50} of 49.7 µg a.i./bee by 1 bee/0.128g, which is based on the weight of an adult honey bee. EECs (µg a.i./g of bee) calculated by T-REX for arthropods are divided by the calculated toxicity value for terrestrial invertebrates, which is >388 µg a.i./g of bee. Since the toxicity endpoint for is non-definitive, RQs were not calculated. Potential for risks to terrestrial invertebrates will be discussed in the Risk Description (**Section 5.2**).

5.1.1.b. Terrestrial Plants

Table 5-2 and **Table 5-3** summarize the RQs for terrestrial and semi-aquatic plants exposed to ground and aerial applications of pendimethalin, respectively. An example output terrestrial and semi-aquatic plant RQs derived from the TerrPlant model is provided in **Appendix E**.

Table 5-1. RQs for Terrestrial Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Ground Applications of Pendimethalin via Runoff and/or Spray Drift.

Use pattern	Plant type	Dry area RQ[1]	Semi-aquatic area RQ[1]	Spray drift RQ[1]
Citrus; Nut crops; Grapes (6 lbs a.i./A)	Monocot (non-listed)	**6.00**	**33.00**	**3.00**
	Monocot (listed)	**12.00**	**66.00**	**6.00**
	Dicot (non-listed)	**1.33**	**7.33**	0.67
	Dicot (listed)	**1.90**	**10.48**	0.95
Pome fruits; Sugarcane; Stone fruits; Leafy and stem vegetables; Forage grasses; Various non-agricultural uses[1] (4 lbs a.i./A)	Monocot (non-listed)	**4.00**	**22.00**	**2.00**
	Monocot (listed)	**8.00**	**44.00**	**4.00**
	Dicot (non-listed)	0.89	**4.89**	0.44
	Dicot (listed)	**1.27**	**6.98**	0.63
Uncultivated agricultural areas (fallow land); Turfgrass (golf course, non-residential, commercial) (3 lbs a.i./A)	Monocot (non-listed)	**3.00**	**16.50**	**1.50**
	Monocot (listed)	**6.00**	**33.00**	**3.00**
	Dicot (non-listed)	0.67	**3.67**	0.33
	Dicot (listed)	0.95	**5.24**	0.48
Corn; Cotton; Soybeans; Residential turfgrass; Sod farms (2 lbs a.i./A)	Monocot (non-listed)	**2.00**	**11.00**	**1.00**
	Monocot (listed)	**4.00**	**22.00**	**2.00**
	Dicot (non-listed)	0.44	**2.44**	0.22
	Dicot (listed)	0.63	**3.49**	0.32
Fruiting vegetables; Root crop vegetables; Legumes; Grain crops; Sunflowers (1.5 lbs a.i./A)	Monocot (non-listed)	**1.50**	**8.25**	0.75
	Monocot (listed)	**3.00**	**16.50**	**1.50**
	Dicot (non-listed)	0.33	**1.83**	0.17
	Dicot (listed)	0.48	**2.62**	0.24
Rice; brassica head and stem vegetables, brassica leafy greens (1 lb a.i./A)	Monocot (non-listed)	**1.00**	**5.50**	0.50
	Monocot (listed)	**2.00**	**11.00**	**1.00**
	Dicot (non-listed)	0.22	**1.22**	0.11
	Dicot (listed)	0.32	**1.75**	0.16

Bolded values exceed LOC for plants (RQ≥1.0)

[1]Non-agricultural uses including: grounds/landscape maintenance; ornamental production; commercial/ industrial/ recreational lawns; ornamental nurseries; christmas tree plantations; rights-of-way/fencerows/hedgerows; around paved areas; around commercial, industrial, institutional buildings.

Table 5-2. RQs for Terrestrial Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Aerial Applications of Pendimethalin via Runoff and/or Spray Drift.

Use pattern	Plant type	Dry area RQ	Semi-aquatic area RQ	Spray drift RQ
Citrus; Nut crops; Grapes (6 lbs a.i./A)	Monocot (non-listed)	**18.00**	**45.00**	**15.00**
	Monocot (listed)	**36.00**	**90.00**	**30.00**
	Dicot (non-listed)	**4.00**	**10.00**	**3.33**
	Dicot (listed)	**5.71**	**14.29**	**4.76**
Pome fruits; Sugarcane;	Monocot (non-listed)	**12.00**	**30.00**	**10.00**

Stone fruits; Leafy and stem vegetables; Forage grasses; Various non-agricultural uses[1] (4 lbs a.i./A)	Monocot (listed)	**24.00**	**60.00**	**20.00**
	Dicot (non-listed)	**2.67**	**6.67**	**2.22**
	Dicot (listed)	**3.81**	**9.52**	**3.17**
Uncultivated agricultural areas (fallow land); Turfgrass (golf course, non-residential, commercial) (3 lbs a.i./A)	Monocot (non-listed)	**9.00**	**22.50**	**7.50**
	Monocot (listed)	**18.00**	**45.00**	**15.00**
	Dicot (non-listed)	**2.00**	**5.00**	**1.67**
	Dicot (listed)	**2.86**	**7.14**	**2.38**
Corn; Cotton; Soybeans; Residential turfgrass; Sod farms (2 lbs a.i./A)	Monocot (non-listed)	**6.00**	**15.00**	**5.00**
	Monocot (listed)	**12.00**	**30.00**	**10.00**
	Dicot (non-listed)	**1.33**	**3.33**	**1.11**
	Dicot (listed)	**1.90**	**4.76**	**1.59**
Fruiting vegetables; Root crop vegetables; Legumes; Grain crops; Sunflowers (1.5 lbs a.i./A)	Monocot (non-listed)	**4.50**	**11.25**	**3.75**
	Monocot (listed)	**9.00**	**22.50**	**7.50**
	Dicot (non-listed)	**1.00**	**2.50**	0.83
	Dicot (listed)	**1.43**	**3.57**	**1.19**
Rice; brassica head and stem vegetables, brassica leafy greens (1 lb a.i./A)	Monocot (non-listed)	**3.00**	**7.50**	**2.50**
	Monocot (listed)	**6.00**	**15.00**	**5.00**
	Dicot (non-listed)	0.67	**1.67**	0.56
	Dicot (listed)	0.95	**2.38**	0.79

Bolded values exceed LOC for plants (RQ≥1.0)

[1]Non-agricultural uses including: grounds/landscape maintenance; ornamental production; commercial/ industrial/ recreational lawns; ornamental nurseries; christmas tree plantations; rights-of-way/fencerows/hedgerows; around paved areas; around commercial, industrial, institutional buildings.

5.1.2. Primary Constituent Elements of Designated Critical Habitat

For pendimethalin use, the assessment endpoints for designated critical habitat PCEs involve the same endpoints as those being assessed relative to the potential for direct and indirect effects to the listed species assessed here. Therefore, the effects determinations for direct and indirect effects are used as the basis of the effects determination for potential modification to designated critical habitat.

5.2. Risk Description

The risk description synthesizes overall conclusions regarding the likelihood of adverse impacts leading to a preliminary effects determination (*i.e.*, "no effect," "may affect, but not likely to adversely affect," or "likely to adversely affect") for the assessed species and the potential for modification of their designated critical habitat based on analysis of risk quotients and a comparison to the Level of Concern. The final No Effect/May Affect determination is made after the spatial analysis is completed at the end of the risk description, Section 5.2.4. In Section 5.2.4, a discussion of any potential overlap between areas where potential usage may result in LAA effects and areas where species are expected to occur (including any designated critical

habitat) is presented. If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects a No Effect determination is made.

If the RQs presented in the Risk Estimation (Section 5.1) show no direct or indirect effects for the assessed species, and no modification to PCEs of the designated critical habitat, a preliminary "no effect" determination is made, based on pendimethalin's use within the action area. However, if LOCs for direct or indirect effect are exceeded or effects may modify the PCEs of the critical habitat, the Agency concludes a preliminary "may affect" determination for the FIFRA regulatory action regarding pendimethalin. A summary of the risk estimation results (a preliminary effects determination of "no effect" or "may affect") are provided in **Table 5-4** for direct and indirect effects to the listed species assessed here and in **Table 5-5** for the PCEs of their designated critical habitat.

Table 5-3. Risk Estimation Summary for Pendimethalin - Direct and Indirect Effects

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation	Assessed Species Potentially Affected
Terrestrial Invertebrates	Listed Species (Yes)	While potential for direct effects is uncertain given the lack of acceptable toxicity data at environmentally relevant exposure concentrations, evidence suggests risks to the BCB are likely.	Direct Effects: BCB
Terrestrial Plants - Monocots	Non-listed Species (Yes)	RQs > 1.0 (the LOC) for terrestrial and semi-aquatic plants exposed to spray drift or runoff for all uses.	Indirect Effects: BCB
	Listed Species (Yes)	RQs > 1.0 (the LOC) for terrestrial and semi-aquatic plants exposed to spray drift or runoff for all uses.	Indirect Effects: BCB
Terrestrial Plants - Dicots	Non-listed Species (Yes)	RQs > 1.0 (the LOC) for terrestrial and semi-aquatic plants exposed to spray drift or runoff for all uses.	Indirect Effects: BCB
	Listed Species (Yes)	RQs > 1.0 (the LOC) for terrestrial and semi-aquatic plants exposed to spray drift or runoff for all uses.	Indirect Effects: BCB

Table 5-4. Risk Estimation Summary for Pendimethalin – Effects to Designated Critical Habitat. (PCEs)

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation	Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action
Terrestrial Invertebrates	Listed Species (Yes)	While potential for direct effects is uncertain given the lack of acceptable toxicity data at	BCB

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation	Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action
		environmentally relevant exposure concentrations, evidence suggests risks to the BCB are likely.	
Terrestrial Plants - Monocots	Non-listed Species (Yes)	RQs > 1.0 (the LOC) for terrestrial and semi-aquatic plants exposed to spray drift or runoff for all uses.	BCB
	Listed Species (Yes)	RQs > 1.0 (the LOC) for terrestrial and semi-aquatic plants exposed to spray drift or runoff for all uses.	BCB
Terrestrial Plants - Dicots	Non-listed Species (Yes)	RQs > 1.0 (the LOC) for terrestrial and semi-aquatic plants exposed to spray drift or runoff for all uses.	BCB
	Listed Species (Yes)	RQs > 1.0 (the LOC) for terrestrial and semi-aquatic plants exposed to spray drift or runoff for all uses.	BCB

Following a preliminary "may affect" determination, additional information is considered to refine the potential for exposure at the predicted levels based on the life history characteristics (*i.e.*, habitat range, feeding preferences, *etc.*) of the assessed species. Based on the best available information, the Agency uses the refined evaluation to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that are "likely to adversely affect" the assessed species and its designated critical habitat.

The criteria used to make determinations that the effects of an action are "not likely to adversely affect" the assessed species or modify its designated critical habitat include the following:

- Significance of Effect: Insignificant effects are those that cannot be meaningfully measured, detected, or evaluated in the context of a level of effect where "take" occurs for even a single individual. "Take" in this context means to harass or harm, defined as the following:
    - Harm includes significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.
    - Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.
- Likelihood of the Effect Occurring: Discountable effects are those that are extremely unlikely to occur.
- Adverse Nature of Effect: Effects that are wholly beneficial without any adverse effects are not considered adverse.

A description of the risk and effects determination for each of the established assessment endpoints for the BCB and its designated critical habitat is provided in **Section 5.2.1** and **5.2.2**. The effects determination section will start with a discussion of the potential for direct effects, followed by a discussion of the potential for indirect effects. This discussion does not consider the spatial analysis. The section will end with a discussion on the potential for modification to the critical habitat from the use of pendimethalin. Finally, in Section 5.2.4, a discussion of any potential overlap between areas of concern and the species (including any designated critical habitat) is presented. If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects a No Effect determination is made.

5.2.1. Terrestrial Invertebrates

5.2.1.a. Direct Effects

While RQs were not calculated for terrestrial invertebrates because of a non-definitive toxicity endpoint (> 388 µg a.i./g of bee), EECs generated for the arthropod can be compared to the available toxicity data to determine whether there is potential for risk. Arthropod EECs ranged from 94 to 564 µg a.i./g of bee, which represents 24 to 145% of the lowest dose tested in the submitted acute contact study. Since sublethal effects were not described in the study, it is uncertain how much less toxic the true toxicity endpoint is from the highest dose tested in the study. To further put potential exposures in context, in order for risks to terrestrial invertebrates from exposure to pendimethalin to be below the Agency's interim LOC (0.05), the acute toxicity LD_{50} would need to be up to 30 times greater than the highest dose tested in the available study. An additional unreviewed study submitted to the European Union in support of registration of pendimethalin suggests that the acute contact LD_{50} for the honey bee is actually 100 µg a.i./bee (781 µg a.i./g of bee) (Report # ETX 99-227; as reported in European Commission 2003). Though the acceptability of this study for use in risk assessment is unknown, it indicates that terrestrial invertebrates may be at risk from pendimethalin use, with arthropod EECs ranging from 12 to 72% of the toxicity endpoint. Incident data were not submitted for terrestrial invertebrates and are not available; however, this does not mean that an invertebrate kill did not occur, but that it was potentially not reported. Based on this available information, **pendimethalin does have the potential to directly affect the BCB.**

5.2.2. Terrestrial plants

5.2.2.a. Indirect Effects

The BCB has an obligate relationship with several terrestrial plant species. For example, the main food sources for the larval stage of the BCB are the dwarf plantain, purple owl's clover, and the exserted paintbrush, while the adult BCB feeds on nectar from various species that thrive in serpentive grasslands. In addition, terrestrial plants serve several important habitat-related functions for the BCB. In addition to providing habitat and food sources, terrestrial vegetation also provides shelter and cover from predators while foraging.

As discussed above, the RQs for listed and non-listed monocots (2.0 – 90 and 0.50 – 45, respectively) and listed and non-listed dicots (0.32 – 14.29 and 0.11 – 10, respectively) indicate that **pendimethalin does have the potential for direct effects to plants**. Potential effects are greatest for semi-aquatic plants exposed to pendimethalin from a combination of spray drift and runoff. In addition, plant incident data is available for a number of crop, grass, and ornamental plant species, suggesting pendimethalin has the potential for plant damage (see section **4.4.2** for details on the individual incidents). Furthermore, spatial distribution maps for BCB indicate overlap between habitat and the pendimethalin use footprint, which is ubiquitous given the registered use patterns in California. Since the BCB relies on plants for shelter and/or food, **there is a potential for <u>indirect effects</u> during at least some portion of the BCB life-cycle.**

5.2.3. Modification of Designated Critical Habitat

Based on the weight-of-evidence and particularly the output of the RQ calculations whereby direct and indirect effects are expected for certain species (see the table above), **there is a potential for the modification designated critical habitat** (*i.e.*, particularly in reference to the species with a designated critical habitat designation including BCB.)

5.2.4. Spatial Extent of Potential Effects

Since LOCs are exceeded, analysis of the spatial extent of potential LAA effects is needed to determine where effects may occur in relation to the treated site. If the potential area of usage and subsequent Potential Area of LAA Effects overlaps with BCB habitat or areas of occurrence and/or critical habitat, a likely to adversely affect determination is made. If the Potential Area of LAA Effects and the BCB habitat and areas of occurrence and/or critical habitat do not overlap, a no effect determination is made.

To determine this area, the footprint of pendimethalin's use pattern is identified, using corresponding land cover data, see Section 2.7. The land cover classes used to determine the use footprint include cultivated orchard, vineyard, pasture, hay, turf, and all urban NLCD categories based on the numerous potential agricultural, orchard, and non-agriculatural use sites. Actual usage is expected to occur in a smaller area as the chemical is only expected to be used on a portion of the identified area. The spatial extent of the effects determination also includes areas beyond the initial area of concern that may be impacted by spray drift (Use Footprint + distance down wind from use sites where organisms relevant to the assessed species may be affected). The determination of the buffer distance and downstream dilution for spatial extent of the effects determination is described below.

5.2.4.a. Spray Drift

In order to determine terrestrial habitats of concern due to pendimethalin exposures through spray drift, it is necessary to estimate the distance that spray applications can drift from the treated area and still be present at concentrations that exceed levels of concern. For the flowable uses, a quantitative analysis of spray drift distances was completed using AgDRIFT (v. 2.01) using default inputs for aerial applications (*i.e.*, ASAE Very Fine to Fine). Listed and non-listed

plant species endpoints for terrestrial exposure were considered.

Table 5-5. Buffers for Listed and Non-listed Terrestrial Species using AgDRIFT

Endpoint	Species	Max Application Rate	Fraction of Applied	Type of Assessment	Buffer
NOAEC = 0.0008 lb a.i/A (Listed species)	Ryegrass (vegetative vigor- MRID 42372203) (Monocot)	6.0 lb a.i./A	LOC/RQ = 0.033	Terrestrial (Tier 1)	110 feet[1]
EC_{25} = 0.034 lb a.i./A (Non-listed species)	Ryegrass (vegetative vigor- MRID 42372203) (Monocot)	6.0 lb a.i./A	LOC/RQ = 0.067	Terrestrial (Tier 1)	144 feet[2]

[1] All aerial applications have a 175 ft buffer when endangered plant species are present. This buffer is already taken into account in AgDRIFT, therefore an additional buffer of 110 feet is required (285 ft -175 ft = 110 ft).
[2] Larval BCB has obligate relationships with the following non-listed plant species: dwarf plantain, purple owl's clover, and exserted paintbrush.

5.2.4.b. Overlap of Potential Areas of LAA Effect and Habitat and Occurrence of BCB

The spray drift analysis helped to identify areas of potential effect to the BCB from registered uses of pendimethalin. The Potential Area of LAA Effects on survival, growth, and reproduction for the BCB from pendimethalin spray drift extend from the site of application to greater than 1000 feet from the site of application. A map indicating the overlap between the habitat space for the BCB and the use footprint area is provided in **Figure 5-1** below.

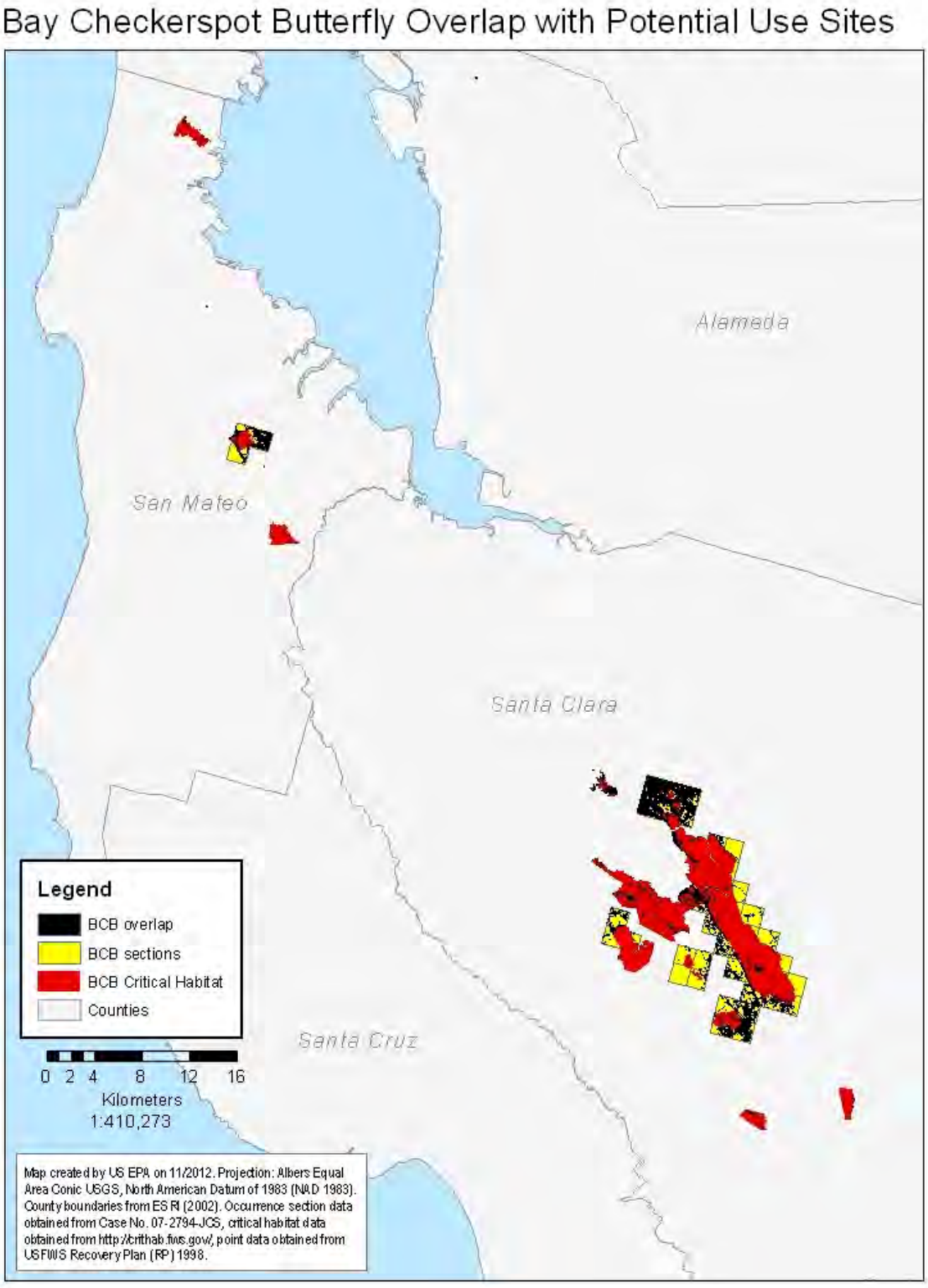

Figure 5-1. Bay Checkerspot Butterfly overlap with potential pendimethalin use sites in California.

5.3. Effects Determinations

5.3.1. Assessed Species

The BCB has the potential for direct and indirect effects as a result of pendimethalin exposure at the registered use rates.

Therefore, the Agency makes a **may affect, and likely to adversely affect** determination for the BCB and a **habitat modification determination** for its designated critical habitat based on the potential for direct and indirect effects and effects to the PCEs of critical habitat.

5.3.2. Addressing the Risk Hypotheses

In order to conclude this risk assessment, it is necessary to address the risk hypotheses defined in Section 2.9.1. Based on the conclusions of this assessment, none of the hypotheses can be rejected, meaning that the stated hypotheses represent concerns in terms of direct and indirect effects of pendimethalin on the BCB and its designated critical habitat.

Risk hypotheses are specific assumptions about potential adverse effects (*i.e.*, changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (USEPA, 1998). For this assessment, the risk is stressor-linked, where the stressor is the release of pendimethalin to the environment. The following risk hypotheses are confirmed in this assessment:

The labeled use of pendimethalin within the action area may:

- directly affect BCB by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect BCB and/or modify their designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect BCB and/or modify their designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range;

6. Uncertainties

Uncertainties that apply to most assessments completed for the San Francisco Bay Species Litigation are discussed in Attachment I. This section describes additional uncertainties specific to this assessment.

6.1. Exposure Assessment Uncertainties

6.1.1. Terrestrial Exposure Assessment Uncertainties

6.1.1.a. T-REX

Although there may be multiple pendimethalin applications at a single site, it is unlikely that the same organism would be exposed to the maximum amount of spray drift from every application made. In order for an organism to receive the maximum concentration of pendimethalin from multiple applications, each application of pendimethalin would have to occur under identical atmospheric conditions (*e.g.*, same wind speed and – for plants – same wind direction) and (if it is an animal) the animal being exposed would have to be present directly downwind at the same distance after each application. Although there may be sites where the dominant wind direction is fairly consistent (at least during the relatively quiescent conditions that are most favorable for aerial spray applications), it is nevertheless highly unlikely that plants in any specific area would receive the maximum amount of spray drift repeatedly. It appears that in most areas (based upon available meteorological data) wind direction is temporally very changeable, even within the same day.

Additionally, other factors, including variations in topography, cover, and meteorological conditions over the transport distance are not accounted for by the AgDRIFT/AGDISP model (*i.e.*, it models spray drift from aerial and ground applications in a flat area with little to no ground cover and a steady, constant wind speed and direction). Therefore, in most cases, the drift estimates from AgDRIFT/AGDISP may overestimate exposure even from single applications, especially as the distance increases from the site of application, since the model does not account for potential obstructions (*e.g.*, large hills, berms, buildings, trees, *etc*.). Furthermore, conservative assumptions are often made regarding the droplet size distributions being modeled ('ASAE Very Fine to Fine' for orchard uses and 'ASAE Very Fine' for agricultural uses), the application method (*e*.g., aerial), release heights and wind speeds. Alterations in any of these inputs would change the area of potential effect.

6.2. Effects Assessment Uncertainties

6.2.1. Data Gaps and Uncertainties

All terrestrial plant testing was conducted with the active ingredient (TGAI – technical grade active ingredient) and did not include solvent controls. The use of TEP (typical end-use product) instead of TGAI is recommended for all terrestrial non-target plant studies. Testing with only the TGAI may underestimate toxicity to plants because the TEP may include a solvent or adjuvant which results in additive or synergistic toxicity.

Pendimethalin is rated as practically non-toxic to honeybees. The honeybee contact toxicity data is used as a surrogate assessment endpoint for all terrestrial invertebrates, including the BCB. Because there were no mortalities observed at the highest treatment dose from the available acute honeybee study, and terrestrial EECs calculated in T-REX exceed the highest treatment dose from the study, acute risks to the BCB cannot be precluded. RQs were calculated with this non-definitive endpoint and therefore do not represent a precise estimation of risk. Additionally, chronic toxicity data for the honeybee, or other terrestrial invertebrates, are not available. Without this information risks to growth and fecundity cannot be precluded for the BCB.

In addition, the terrestrial exposure analysis of this risk assessment, the BCB was assumed to occupy either the treated field or adjacent areas receiving a treatment rate on the field. Actual habitat requirements of any particular terrestrial species were not considered, and it was assumed that species occupy, exclusively and permanently, the modeled treatment area. Spray drift model predictions suggest that this assumption leads to an overestimation of exposure to species that do not occupy the treated field exclusively and permanently.

6.2.2. Use of Surrogate Species Effects Data

Guideline toxicity tests and open literature data on pendimethalin are not available for butterflies; therefore, the honey bees (*Apis mellifera*) are used as surrogate species for butterflies and the BCB. Endpoints based on honey bee ecotoxicity data are assumed to be protective of potential direct effects to the butterflies and BCB. Efforts are made to select the organisms most likely to be affected by the type of compound and usage pattern; however, there is an inherent uncertainty in extrapolating across phyla. In addition, the Agency's LOCs are intentionally set very low, and conservative estimates are made in the screening level risk assessment to account for these uncertainties.

6.2.3. Sublethal Effects

When assessing acute risk, the screening risk assessment relies on the acute mortality endpoint as well as a suite of sublethal responses to the pesticide, as determined by the testing of species response to chronic exposure conditions and subsequent chronic risk assessment. Consideration of additional sublethal data in the effects determination t is exercised on a case-by-case basis and only after careful consideration of the nature of the sublethal effect measured and the extent and quality of available data to support establishing a plausible relationship between the measure of effect (sublethal endpoint) and the assessment endpoints. However, the full suite of sublethal effects from valid open literature studies is considered for the characterization purposes.

7. Risk Conclusions

In fulfilling its obligations under Section 7(a)(2) of the Endangered Species Act, the information presented in this endangered species risk assessment represents the best data currently available to assess the potential risks of pendimethalin to BCB its designated critical habitat.

Based on the best available information, the Agency makes a May Affect, Likely to Adversely Affect determination for the BCB. Additionally, the Agency has determined that there is the potential for modification of the designated critical habitat for the BCB from the use of the chemical. Given the LAA determination for BCB and potential modification of designated critical habitat for BCB, a description of the baseline status and cumulative effects is provided in Attachment III.

A summary of risk conclusions and effects determinations for the BCB and its critical habitiat, given the uncertainties discussed in Section 6 and Attachment I, is presented in **Table 7-1** and **Table 7-2**. Use specific effects determinations are provided in **Table 7-3**.

Table 7-1. Effects Determination Summary for Effects of Pendimethalin on the BCB

Species	Effects Determination	Basis for Determination
Bay Checkerspot Butterfly (*Euphydryas editha bayensis*)	May Affect, Likely to Adversely Affect (LAA)	**Potential for Direct Effects** • While potential for direct effects is uncertain given the lack of acceptable toxicity data at environmentally relevant exposure concentrations, evidence suggests risks to the BCB are likely. • The species critical habitat and/or occurrence sections overlap with the use footprint **Potential for Indirect Effects** • Habitat modification (RQs range from 0.5 to 95) • The species critical habitat and/or occurrence sections overlap with the use footprint

Table 7-2. Effects Determination Summary for the Critical Habitat Impact Analysis

Designated Critical Habitat for:	Effects Determination	Basis for Determination
Bay Checkerspot Butterfly (*Euphydryas editha bayensis*)	Habitat Modification	• While potential for direct effects is uncertain given the lack of acceptable toxicity data at environmentally relevant exposure concentrations, evidence suggests risks to the BCB are likely. • Risk to terrestrial plants and thus BCB habitat (esp. dwarf plantain, purple owl's clover, exserted paintbrush). (RQs range from 0.5 to 95) • Area of overlap between species habitat/critical habitat/ or occurrence sections and the initial area of concern or use footprint

Table 7-3. Use Specific Summary of The Potential for Adverse Effects to Terrestrial Taxa

Uses	Potential for Effects to Identified Taxa Found in the Terrestrial Environment:		
	BCB and Invertebrates (Acute)[1]	Dicots[2]	Monocots[2]
Citrus; Nut crops; Grapes	Yes	Yes	Yes
Stone fruits; Leafy and stem vegetables; Forage grasses; Olives; Loquat; Pomegranates; Asparagus; Pome fruits; Sugarcane	Yes	Yes	Yes
Flavoring and spice crops; Corn; Cotton; Soybeans	Yes	Yes	Yes
Fruiting vegetables; Root	Yes	Yes	Yes

crop vegetables; Legumes; Grain crops; Tobacco; Sunflowers; Strawberries			
Peanuts	Yes	Yes	Yes
Onions	Yes	Yes	Yes
Rice	Yes	Yes	Yes
Figs; Ornamental nurseries; Christmas tree plantations; Rights-of-way/fencerows/hedgerows; Around paved areas	Yes	Yes	Yes
Sod farms; Rangeland; Golf courses; Airports/landing fields	Yes	Yes	Yes
Forestry	Yes	Yes	Yes
Commercial/ industrial/ recreational lawns; Residential lawns	Yes	Yes	Yes

1 A yes in this column indicates a potential for direct effect to BCB.
2 A yes in this column indicates a potential for indirect effects to BCB. For the BCB this is based on the listed species LOC because of the obligate relationship with terrestrial monocots and dicots.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated.

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the listed species and its resources (*i.e.*, food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (*i.e.*, attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of BCB life stages within the action area and/or applicable designated critical habitat. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the assessed species.
- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects

on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.

- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual species and potential modification to critical habitat.

8. References

A bibliography of ECOTOX references, identified by the letter E followed by a number, is located in Appendix .

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9. MRID List

Pendimethalin Fate Bibliography

Note to Reviewer

There are many 5 Year soil dissipation and residue studies in our folders that are not captured by OPPIN. Authors are Roman, Tondreau and others about 1979 all under one MRID 00046795. Most are invalid

See 2037406, 2037408, 2037409, 2037422, 2037423, 2037424, 2037425, 2037426, 2037427, 2037428, 2037429, 2037430, 2037431, 2037432, 2037433

161-1 Hydrolysis

MRID	Citation Reference
46287	Zulalian, J.; Eisner, S.K. (1974) Prowl Herbicide: A Study on the Behavior of 14?C-Labeled CL 92,553 in an Hydrolytic Environ- ment: Project No. 2-463. (Unpublished study received Sep 27, 1974 under 5F1556; submitted by American Cyanamid Co., Prince- ton, N.J.; CDL:094674-A)
46296	Zulalian, J.; Fasinski, R.; Eisner, S.K. (1973) CL 92,553: Metabo- lism VII. Fate of Carbon-14 Labeled CL 92,553 (Prowl Herbicide) on Exposure to Sunlight in Water and on Glass and Soil Surfaces: Report No. 2-463. (Unpublished study received Sep 27, 1974 under 5F1556; prepared by American Cyanamid Co., Princeton, N.J.; CDL:094673-R)

109914 Zulalian, J.; Fasinski, R.; Eisner, S. (1973) CL 92,553: Metabo- lism VII. Fate of Carbon-14 Labeled CL 92,553 (Prowl Herbicide) on Exposure to Sunlight in Water and on Glass and Soil Surfaces: PD-M 10:912-958. (Unpublished study received on unknown date under 4G1451; submitted by American Cyanamid Co., Princeton, NJ; CDL:094672-D)

106777 Study in Hydrolytic environment

161-2 Photodegradation-water

MRID	Citation Reference
153763	Sanders, P. (1985) Prowl Herbicide, Pendimethalin (AC 92,553): Photodegradation in Water: Project No. 0166: Report No. PD-M Volume 22-36. Unpublished study prepared by American Cyanamid Co. 32 p.
43808201	Ta, C. (1995) Aqueous Photolysis of AC 92,553: Lab Project Number: ENV 95-028: E-95-04. Unpublished study prepared by American Cyanamid Co. 99 p.
05001076	Open lit on photodecomposition – 11 herbibcides
46296	Zulalian, J.; Fasinski, R.; Eisner, S.K. (1973) CL 92,553: Metabo- lism VII. Fate of Carbon-14 Labeled CL 92,553 (Prowl Herbicide) on Exposure **to Sunlight in Water** and on Glass and Soil Surfaces: Report No. 2-463. (Unpublished study received Sep 27, 1974 under 5F1556; prepared by American Cyanamid Co., Princeton, N.J.; CDL:094673-R)

161-3 Photodegradation-soil

MRID	Citation Reference
46296	Zulalian, J.; Fasinski, R.; Eisner, S.K. (1973) CL 92,553: Metabo- lism VII. Fate of Carbon-14 Labeled CL 92,553 (Prowl Herbicide) on Exposure to Sunlight in Water and on Glass and Soil Surfaces: Report No. 2-463. (Unpublished study received Sep 27, 1974 under 5F1556; prepared by American Cyanamid Co., Princeton, N.J.; CDL:094673-R)
109914	Zulalian, J.; Fasinski, R.; Eisner, S. (1973) CL 92,553: Metabo- lism VII. Fate of Carbon-14 Labeled CL 92,553 (Prowl Herbicide) on Exposure to Sunlight in Water and on Glass and Soil Surfaces: PD-M 10:912-958. (Unpublished study received on unknown date under 4G1451; submitted by American Cyanamid Co., Princeton, NJ; CDL:094672-D)
153764	Mangels, G. (1985) Prowl Herbicide, Pendimethalin (AC 92,553): Photodegradation on Soil: Project No. 0166: Report No. PD-M Volume 22-35. Unpublished study prepared by American Cyanamid Co. 27 p.

162-1 Aerobic soil metabolism

MRID	Citation Reference
46282	Barringer, D.F., Jr.; Haugwitz, M.I.; Eisner, S.K. (1974) CL 92,553: Metabolism XIII. The Behavior of CL 92,553 (Prowl Herbicide) in Soil, Part III. Anaerobic Studies: Project No. 2- 463. (Unpublished study received Sep 27, 1974 under 5F1556; submitted by American Cyanamid Co., Princeton, N.J.; CDL: 094475-I)
40185104	Lavin, M.; Cranor, W. (1987) Aerobic Soil Metabolism of [Carbon 14]-Pendimethalin: Lab. Rept. No. 33731. Unpublished study pre- pared by Analytical Bio-Chemistry Laboratories, Inc. 677 p.

162-2 Anaerobic soil metabolism

MRID	Citation Reference
151795 or 137706	Mangels, G. (1984) Prowl Herbicide, Pendimethalin (CL 92,553): Anaerobic Metabolilsm in Soil from a Rice Field: Project NO. 0470: Rept. No. PD-M Vol. 21-2.1. Unpublished study prepared by American Cyanamid Co. 29 p.
40185105	Lavin, M.; Cranor, W. (1987) Anaerobic Soil Metabolism of [Carbon 14]-Pendimethalin: Lab. Rept. No. 33732. Unpublished study pre- pared by Analytical Bio-Chemistry Laboratories, Inc.

162-3 Anaerobic aquatic metab.

MRID	Citation Reference
40813501	Sanders, P. (1988) Pendimethalin (AC 92,553): Anaerobic Aquatic De- gradation in Soil from a Rice Field: Laboratory Project ID PD-M- 25-25. Unpublished study prepared by American Cyanamid Co. 53 p.
43154701	Mangels, G.; Ahmed, Z. (1994) Pendimethalin Registration Standard--**Response to EFGWB Review.** Unpublished study prepared by American Cyanamid Co. 88 p.
43154702	Mangels, G. (1991) Pendimethalin (AC 92, 553): Anaerobic Aquatic Degradation in Static Canadian Pond Water: Lab Project Number: PD-M 28-5: E-89-30: 0466. Unpublished study prepared by American Cyanamid Co. 117 p.

162-4 or 835.4300 Aerobic aquatic metab.

MRID	Citation Reference
47385201	Ebert, D. (2008) Degradation of Pendimethalin (BAS 455 H) in Water/Sediment Systems Under Aerobic Conditions: Final Repost. Project Number: 169996, 2004/1022517. Unpublished study prepared by BASF Aktiengesellschaft. 75 p.

163-1 Leach/adsorp/desorption

MRID	Citation Reference
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163-2 Volatility - lab

MRID	Citation Reference
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164-1 Terrestrial field dissipation

MRID	Citation Reference

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106782	Zulalian, J.; Godney, R.; Fasinski, R. (1973) CL 92,553--Metabo- lism V: Fate of Carbon-14 Labeled CL 92,553 (Prowl Herbicide) in Soil: PD-M 10:837-911. (Unpublished study received on un- known date under 4G1451; submitted by American Cyanamid Co., Princeton, NJ; CDL:094672-B)
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164-2 Aquatic field dissipation

MRID	Citation Reference
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165-0 Accumulation Studies -- General

MRID	Citation Reference
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165-1 Confined rotational crop

MRID	Citation Reference
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165-4 Bioaccumulation in fish

MRID	Citation Reference
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Drift study – 00029344= 2037410

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71-1 Avian Single Dose Oral Toxicity

MRID	Citation Reference
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71-2 Avian Dietary Toxicity

MRID	Citation Reference
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71-4 Avian Reproduction

MRID	Citation Reference
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72-1 Acute Toxicity to Freshwater Fish

MRID	Citation Reference
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72-2 Acute Toxicity to Freshwater Invertebrates

MRID	Citation Reference
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153772	Forbis, A.; Georgie, L.; Burgess, D. (1985) Acute Toxicity of AC 92,553 4E to Daphnia magna: Static Acute Toxicity Report #33409. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 39 p.

72-3 Acute Toxicity to Estuarine/Marine Organisms

MRID	Citation Reference
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72-4 Fish Early Life Stage/Aquatic Invertebrate Life Cycle Study

MRID	Citation Reference
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72-5 Life cycle fish

MRID	Citation Reference
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72-6 Aquatic org. accumulation

MRID	Citation Reference
156726	Forbis, A.; Burgess, D.; Burnett, J. (1986) Uptake, Depuration and Bioconcentration of [Carbon-14]-AC 92,553 by Bluegill Sunfish (Lepomis macrochirus): Final Report #33408. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 277 p.

123-1 Seed germination/seedling emergence and vegitative vigor

MRID	Citation Reference
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123-2 Aquatic plant growth

MRID	Citation Reference
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