APPENDIX K. ANALYSIS OF HERBICIDES UNIQUE TO THE NAVAJO NATION IWMP

Introduction

This appendix compiles information on six herbicides unique to the Navajo Nation Integrated Weed Management Plan (NNIWMP). While most of the herbicides proposed for use in the NNIWMP are analyzed for their potential environmental impacts in other NEPA documents incorporated by reference, six of the herbicides have not been previously assessed. The NEPA documents incorporated by reference for this PEIS include:

- Final Environmental Impact Statement for Integrated Treatment of Noxious or Invasive Weeds for the Coconino, Kaibab, and Prescott National Forests within Coconino, Gila, Mojave, and Yavapai Counties, Arizona (2005)
- Final Programmatic Environmental Impact Statement: Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States (2007)
- Final Programmatic Environmental Impact Statement for Vegetation Treatments Using Aminopyralid, Fluroxypyr, and Rimsulfuron on Bureau of Land Management Lands in 17 Western States (2016)

In addition to these NEPA documents, the U.S. Forest Service prepared risk assessments for several of the herbicides proposed in the NNIWMP. These risk assessments provide in-depth and technical information on the environmental fate, human health risks, exposure risk assessments, and ecological risk assessments. Environmental fate assessments provide an evaluation of how herbicides may persist and or move around in treated areas. This information is valuable for evaluating potential risks to soils and water resources. Human health risks review studies and information on how the herbicides may affect human health based on toxicology information. These assessments also include an analysis of whether the public, applicators, and other workers are at risk of encountering harmful concentrations of herbicides based on the herbicide's label instructions, and approved application rates. This information is used to assess potential risks to public health.

Finally, ecological risk assessments examine each herbicide's toxicity on terrestrial and aquatic organisms, including birds, reptiles, amphibians, mammals, and plants. While the EPA does require herbicide manufacturers to conduct toxicology studies as part of its registration process, it does not require companies to complete studies for each class of animals or plant forms. As a result, some toxicology information is not well known for some animals or may not be comparable between herbicides. To address this issue, many of the wildlife and plant studies may require that only the tested species be listed to allow for applicable comparisons and denote areas where information may be lacking. Overall, the ecological risk assessments prepared by the USFS are used in the PEIS in evaluating potential risks and impacts for wildlife and vegetation.

Herbicides Evaluated in Detail

While the BIA has utilized this information and incorporated into the PEIS for the NNIWMP, seven herbicides proposed under the action were not evaluated in any of these documents. These herbicides are listed below with the brand name products that may include them in parentheses. Because brand name herbicides may contain one or more active ingredients or may change formulations over time, the analysis refers to the herbicides by active ingredients only. The active ingredients are what the U.S. EPA requires manufacturers to develop their ecological, environmental, and human health analyses on. Thus, familiarity with the active ingredients is essential when selecting herbicides for a project and for any related environmental analyses.

- Dichlobenil (Redeem, Casoron)
- Metribuzin (Sencor)
- Paraquat (Gramoxone)
- Pendimethalin (Pendulum)
- Prodiamine (Evade)
- Thifensulfuron methyl (Volta)

For this PEIS, information was compiled from existing peer-review studies and U.S. EPA product registration reports to evaluate the potential risks they may pose to human health and the environment. This technical information has been compiled here for reference.

Herbicide analysis requires detailed, technical studies that look at potential side effects, model potential mobility of chemical agents, and an understanding of chemical toxicology. This analysis evaluates a variety of studies with laboratory animals or plants exposed to a wide array of herbicide concentrations. Such studies serve as proxies for how the herbicide may interact with humans or other animals and plants with similar biology. While they can provide valuable information on how herbicides may affect living organisms, they cannot be taken as full evaluations of the potential risks herbicides pose when use. Many of these studies have time constraints that make it hard to fully evaluate the potential risks of long-term exposure. Others may not evaluate some animal classes in their toxicology studies, and thus have incomplete information.

This appendix will provide the detailed analysis for these seven herbicides in for the resources analyzed in the Draft PEIS.

Soils and Water

The environmental fate of an herbicide determines its risk of remaining at treated sites, where it may expose the public, or travel to other areas and affect resources there. The risks depend on how much herbicides is applied, how long it takes to degrade, and how it dissolves in water. These factors are important in evaluating whether herbicide applications can be transported from sites at high enough concentrations to affect vegetation, wildlife, or the public. The U.S. EPA considers these factors when setting herbicide application limits for concentrations used, how frequently they are applied, and where they can be applied.

The fate of herbicides in the environment often depends on the interactions between soil and water. Risks to air quality are less of a concern as most herbicides do not remain airborne long after they are applied. They are also often mixed with other ingredients to increase their droplet size and weight to prevent airborne contamination. However, for herbicide applications under this plan, after sites are sprayed with herbicide, there is a risk that the herbicide may soak, or leach, into the ground and travel to groundwater reservoirs or to nearby open water through surface runoff or wind erosion. If sites are treated with high enough concentrations at frequent enough intervals, these risks could result in water contamination or indirect impacts to nearby vegetation or wildlife.

Soils

Herbicides vary in how they interact with soils and whether they can remain at sites for extended periods after they are applied. The most important factors in determining the impacts of an herbicide on soil are its mobility, persistence, and how it breaks down or degrades. These factors are determined by each herbicide's chemical properties, such as adsorption or affinity to soil particles, solubility, chemical half-life, and volatilization. Soil properties that influence the fate of herbicides in soils include organic matter content, pH, temperature, moisture content, soil texture and composition, climate, and microbial activity. Most herbicides degrade over time due to physical and chemical processes in soil and water. Herbicide degradation generally decreases with soil depth, as light, water, and microorganisms become less available. Persistence and mobility of herbicides may also be influenced by the formulation of the active ingredient. The overall impacts of herbicides on soil resources would depend on which herbicides are selected for a given project, the proposed application rates, and the frequency of retreatments.

Below are the environmental fates for the herbicides based on soil adsorption, water solubility, overall persistence in the environment, and degradation mechanisms to determine how long each herbicide may remain in the soils at a particular site.

Dichlobenil is considered moderately persistent in soils with an average half-life of 60 days. Its primary means of degradation is through microbial decomposition, which metabolizes the herbicide into 2,6-dichlorobenzamide (BAM) (BPA 2008). It also has moderate mobility in soils, with a soil adsorption rate (K_{oc}) of 400 (BPA 2008)

Metribuzin is considered moderately persistent in soils with a half-life that varies between to 1 to 2 months depending on climatic conditions and soil texture. It has a higher soil adsorption rate in soils with high clay or organic content but can leach through soils with high sand content. Its main mechanism for degradation is through microbial composition, which is fastest under aerobic conditions and at high temperatures (U.S. EPA 1985).

Paraquat has a low risk of soil mobility due to its high soil adsorption rate but can remain on sites for long periods of time due to its prolonged half-life, which can vary from 60 day to years depending on conditions. While it is soluble in water, it binds so quickly and strongly to soils that it does not stay in solution. Its soil binding strength also limits the ability of it to breakdown through photodegradation and microbial degradation (U.S. EPA 2019a)

Pendimethalin has a low risk of soil mobility due to its strong affinity for soil particles and can remain on sites for prolonged periods of time, which can decrease with increased temperature, moisture, and soil carbon. Its main method of decomposition is through microbial metabolism and volatilization (U.S. EPA 1997a)

Prodiamine is considered relatively immobile in soils due to its strong affinity for soils and it does not persist for long at sites. It can degrade rapidly through photodegradation and is also metabolized through microbial activity, which is higher under anerobic conditions with an average half-life of approximately 2 months (U.S. EPA 1992)

Thifensulfuron methyl is mobile in soils with a soil adsorption rate (K_{foc}) of 28. However, it does not persist long at sites due to its ability to degrade through microbial metabolism and photodegradation (U.S. EPA 2015).

Water

While only three of the herbicides proposed in the Navajo Nation IWMP have Navajo Nation EPA water quality standards associated with them, all herbicides may have the potential to persist accumulate in water depending on how they behave in the environment. Herbicides may be transported to open water if through surface runoff or wind erosion. If they have a higher affinity for water, they may transfer from soils to water, where they may pose a risk to nearby vegetation, wildlife, or humans. Below is a summary of the six herbicides potential risks to water quality based on their environmental fates.

Dichlobenil has moderate potential to leach through soils and contaminate ground water. It does have a high risk of contaminating surface water due to its moderate affinity for soils and moderate water solubility. However, microbial metabolism of dichlobenil may limits its long term persistence in water (BPA 2008)

Metribuzin has a higher potential to contaminate groundwater in areas with sandier soils, due to its limit affinity for sand particles. Its variable soil adsorption rate and moderate water solubility also increases its potential to contaminate surface water. There have been reported cases of surface water contamination in Ohio rivers and Iowa wells (U.S. EPA 1985).

Paraquat's strong soil affinity reduces its potential to contaminate water as it is less likely to dissolve in water or leach through soils. Thus it presents a low risk for groundwater or surface water contamination (U.S. EPA 2019a)

Pendimethalin has a low risk for ground water contamination due to its strong affinity for soil particles. It could contaminate surface water through spray drive or runoff events but its affinity for soils would likely reduces its risks of contaminating open water for long (U.S. EPA 1997).

Prodiamine has a low risk of contaminating groundwater due to its high affinity for soils. Its soil adsorption rate and its ability to degrade in sunlight also limits its ability to contaminate surface water (U.S. EPA 1992).

Thifensulfuron methyl could contaminate ground water due to its mobility in soils and high water solubility. However, its ability to degrade through microbial decomposition in aerobic and anaerobic conditions would limits its persistence for long. It does carry a moderate risk for surface water contamination, but it would be less likely than groundwater due its ability to degrade fast when exposed to sunlight (U.S. EPA 2015)

Vegetation

The assessments conducted by the BLM, USFS, and U.S. EPA Registration Eligibility Decision documents use modeling to estimate the probability of herbicides to move via off-site drift, surface runoff, and wind erosion based on different application methods, chemical composition, environmental properties, and toxicology information. The analyses look at the toxicity of the herbicides on a variety of plant species, such as common crops, grasses, and surrogate species for federally listed species. This information is then used to assess the impacts of herbicides on non-target weed species. Non-target weed species are separated into sensitive species and tolerant species. Sensitive species are often species that share common characteristics with the target species, such as form (grass, herbaceous, woody) and duration (annual vs. perennial). Sensitive species can also include federally or tribally listed threatened, endangered, or sensitive species. Tolerant plant species are those that are not expected to be harmed by the herbicide based on its selectivity or its mode of action on the target plant. For example, grasses would be a tolerant plant species for herbicides that are selective to broadleaf weeds or dicots.

The BLM and USFS use a series of landscape modeling tools for their analyses to look at potential exposure related to off-site drift, wind erosion, surface runoff, and ground water modeling. The USEPA uses models to examine runoff and generic environmental presence over time along with studies and incident reports to examine the ecological impacts of herbicides to decide labeling and use. The USEPA analyses, however, often do not model impacts of specific application methods and do not associate risks of exposure with distance to treatment site or environmental conditions. It is important to note that all modeling and analyses are general in nature and are not able to account for impacts to all native species or crops found on the Navajo Nation. Such risk assessments only provide a general idea of impacts associated with each of the herbicides covered under this plan.

Dichlobenil

Dichlobenil is a broad-spectrum herbicide that is selective for annual and perennial grasses, broadleaf weeds, and woody plants. It is classified as a cellulose inhibitor and works by disrupting the production of cellulose need to build cell walls. The herbicide works most strongly on growing points and root tips of plants, allowing it to be used as both a pre-emergent and post-emergent herbicidal treatment. It is known to reduce the growth of mycorrhizal fungi for some tree species (Hamel et al. 1994), which could impact growth and establishment of some tree species. Additionally, its major metabolite, 2,6-dichlorobenzamide (BAM) has similar impacts within treated areas and can persist within treated areas for longer periods than the parent chemical (U.S. EPA 1998). Dichlobenil is approved for use under Alternative 2 for broadcast ground applications and spot treatments.

Surface runoff does pose a significant risk to sensitive plants as dichlobenil is moderately mobile in coarser soils and can be persistent within water (Stavola and Turner 2003). This increases the potential for the herbicide to be transported off-site during major storm events. U.S. EPA modeling suggests that sensitive non-target plants may be at risk of damage if concentrations of dichlobenil exceed 0.23 lb/ac in associated runoff (U.S. EPA 1998). The U.S. EPA estimates assumes that approximately 2% of applied dichlobenil can potentially be transported from the treatment site through surface runoff. The degree of damage risk increases with increasing application rates which can range from 2-20lbs/ac. Some impacts may also be associated with off-site drift from broadcast treatments. However, these have not been adequately modeled or investigated based on method or application rate.

Metribuzin

Metribuzin is a selective herbicide used for the treatment of broadleaf weeds and grasses. It is classified as a Photosystem II inhibitor, which blocks the transfer of electrons during photosynthesis causing damage to chlorophyll and several lipids and proteins and resulting in abnormal growth and death. It can be used as both a pre-emergent and post-emergent herbicide for the control of weeds such as thistles, Dalmatian toadflax, kochia, field bindweed, and johnsongrass. Under Alternative 2, metribuzin can be used in aerial broadcast, ground broadcast, and spot treatments.

Off-site drift has the potential to cause significant risks to sensitive plant species within 15 feet of the treated area. Metribuzin, as well as at least one of its metabolites, is considered highly mobile in soil, and therefore surface runoff could also pose serious risks to sensitive plant species. Additionally, wind erosion could potentially cause damage to sensitive species, as the compound shows low to moderate persistence in the soil, with a half-life of up to approximately 3 weeks depending on soil type (EFSA 2006).

Paraquat

Paraquat is a selective herbicide used to control annual broadleaf weeds and grasses. It is classified as a Photosystem I inhibitor, meaning it interrupts the exchange of electrons during photosynthesis, initiating a chain of oxidation and reduction reactions that eventually weaken the integrity of cell membranes causing leaf wilt and desiccation. Paraquat is used as both a pre-emergent and post-emergent herbicide and has shown to be effective in the control of musk thistle, cheatgrass, and Russian thistles. Under Alternative 2, paraquat would be approved for aerial broadcast, ground broadcast, and spot application treatments.

Off-site drift from aerial applications is expected to result in the most impact to non-target plant species outside of the treatment area. U.S. EPA analysis determined that damage could happen to sensitive plant species at higher application rates (max rate 1lb a.i./ac) but that damage from drift or runoff was less likely at lower application rates (0.07 lb a.i./ac) (U.S. EPA 1997). Their analysis also indicated that aerial applications at the higher rate would likely pose a risk to non-target plants but would likely not cause harm during ground applications.

Because paraquat binds strongly to soil particles, wind erosion and surface run off are not likely to impact non-target plant species outside of the treatment area (EPA 1997).

Pendimethalin

Pendimethalin is a selective herbicide used to control broadleaf weeds and grasses and is approved for pre-emergent use. It is classified as a mitosis inhibitor, where it disrupts the formation of microtubules in dividing cells, preventing cell growth, seeding development and roots. It is most effective on roots of developing weeds. Under Alternative 2, pendimethalin can be used for aerial broadcast, ground broadcast, and spot applications. It is effective for the treatment of kochia and rescuegrass.

Off-site spray drift of broadcast applications of pendimethalin could potentially impact sensitive plant species. The U.S. EPA Spray Drift Task Force did find during its studies that ground broadcast applications could lead to 1% volume of the herbicide traveling 100ft from the treatment site and 5% of aerial applications (U.S. EPA 1996).

Because pendimethalin is persistent within soils and strongly binds to clay particles, it does have the potential to damage sensitive plant species during surface runoff events. The U.S. EPA analysis of pendimethalin characteristics indicate that such damage would occur during heavy rainfall events immediately after applications. However, pendimethalin’s strong affinity for soil particles would reduce the longevity of such impacts (U.S. EPA 1996).

Damage from wind erosion is not seen as a likely risk due to how strongly adsorbed pendimethalin is to soil particles. While events such as dust storms are likely to move soils contaminated with the herbicide outside of the application area, much of the herbicide would be unavailable to plants.

Prodiamine

Prodiamine is a selective herbicide used for the control of annual broadleaf weeds and grasses. It is also classified as a mitosis inhibitor and is most effective as a pre-emergent herbicide. The herbicide kills and prevents seedling growth by interfering with the formation of microtubules in dividing cells. Under Alternative 2, prodiamine can be used in ground broadcast and spot applications.

Prodiamine is highly persistent in soils (soil half-life of up to 120 days) and binds strongly to soil particles (University of Hertfordshire 2013), thus there is the potential off-site transport through surface runoff or wind erosion as sediment is transported away from treated areas. Damage to non-target species from these routes, however, would likely be limited due to its low solubility in water and strong affinity for soil particles.

Overall, aerial and ground broadcast spraying of herbicides have the most potential to impact native plant populations as they are used to treat large areas with little specificity for native plants within the area. Use of broadcast and aerial spraying could impact non-target plants as pesticide drift would also increase. Plants could experience no effect, reduced vigor, or death depending on the sensitivity of the plant species to the specific pesticide and the dose the plant was subjected to. The use of such methods, however, would be limited to areas where noxious weeds have effectively crowded out native vegetation and where plant species of concern are not present. Broadcast spraying would also not be permitted under certain weather conditions, such as windy events or periods where precipitation is anticipated. The mitigation measures specified below would effectively reduce the overall impacts treatments on desired native vegetation within project areas.

Thifensulfuron methyl

Thifensulfuron methyl is a post-emergent herbicide used to control broadleaf weeds. Under Alternative 2, it can be applied through aerial broadcast, ground broadcast, and spot application treatments. Thifensulfuron methyl is classified as an acetolactate synthase (ALS) inhibitor which interferes with a key enzyme in plants used to synthesize necessary amino acids and proteins, eventually resulting in the death of the plant. Thifensulfuron methyl is often used for the control of spreading wallflower and is highly potent even at low application rates. It is often used in combination with tribenuron methyl.

Off-site drift could pose significant damage to sensitive plant species, especially valuable crops. Lee et al. (2005) listed thifensulfuron methyl as one of 28 “high potential risk” herbicides with regard to off-site drift, based on peer-reviewed studies showing damage to non-target species at sublethal levels, and frequency of drift complaints lodged with state and county agriculture agencies.

Surface runoff could also pose significant damage to sensitive vegetation as thifensulfuron is weakly adsorbed to soil particle (particularly in soils with low organic content, as in many areas across the Navajo Nation, fragile or highly erodible soil), increasing the chances of off-site transport (PSD 1991). Risk of damage is most significant in areas with high runoff potential (clay soils and heavy annual rainfall). On the Navajo Nation, the risk of damage from surface runoff would be most pronounced in washes neighboring treatment areas during heavy rainfall events.

Wind erosion also has the potential to cause unintended impacts on nontarget sensitive plant species. With a relatively long half-life in soil (up to approximately 3 weeks), significant quantities of herbicide may be transported off-site by erosion from wind events occurring days or weeks after application (PSD 1991).

Wildlife

Determining potential impacts to wildlife is based on their toxicity to organisms. **Table K-1** below shows the ecotoxicity categories for terrestrial organisms as defined by the U.S. EPA. The terrestrial animal endpoints for acute avian and mammalian assessment includes the lowest tested LD_{50} (medium lethal dose of pesticide that causes 50% lethality of the test population) or LC_{50} (concentration of dietary pesticide that causes lethality in 50% of the test population). For non-target insects the endpoints include an acute, single dose of pesticide that causes 50% mortality in a test population of bees (LD_{50}).

Table K-1. Ecotoxicity Categories for Terrestrial Organisms. (From 40 CFR 156.64: Toxicity Category).

Terrestrial Organism	Very Highly Toxic	Highly Toxic	Moderately Toxic	Slightly Toxic	Practically Non-Toxic
Avian: Acute Oral Concentration (mg/kg-bw)	<10	10-50	51-500	501-2000	>2000
Avian: Dietary Concentration (mg/kg-diet)	<50	50-500	501-1000	1001-5000	>5000
Wild Mammals: Acute oral concentration (mg/kg-bw)	<10	10-50	51-500	501-2000	>2000
Non-target insects: Acute concentration (µg/bee)		<2	2-11		>11

These toxicity standards were used in evaluating the U.S. EPA Eligibility Registration/Reregistration Decision Documents for the six herbicides proposed for use by the BIA that have not been previously evaluated for risk by the BLM or USFS. They are presented below.

Dichlobenil –Dichlobenil is slightly to moderately toxic to mammals with an acute oral LD_{50} ranging from greater than 3,160 mg/kg for rats to 270 mg/kg for rabbits. Oral doses of 200 to 400 mg/kg of dichlobenil to rabbits caused an increase in SDH (serum sorbitol dehydrogenase) activity and death in some animals (U.S. EPA 1998). The same study showed that rats receiving lethal doses of dichlobenil suffered liver and kidney damage, while rabbits suffered centrilobular necrosis of the liver. The dermal "no observable effect level" (NOEL) for rabbits has been reported as 100 mg/kg/day, and the acute dermal LD_{50} has been reported as 1,350 mg/kg/day (U.S. EPA 1998). No significant local skin reactions were noted at any test concentration. Dietary NOELs of 50 ppm have been reported for mice, rats, rabbits, and pigs (U.S. EPA 1998). Neurotoxic effects of dichlobenil have been observed in mammals, including depression in rabbits (U.S. EPA 1998) and muscle hypotomus in rats exposed to the dichlobenil degradate 2,6-dichlorobenzamide (U.S. EPA 1998).

Toxicity to birds is slight to very slight, with LD_{50} ranging from greater than 1,189 mg/kg/day for pheasants to greater than 5,000 mg/kg/day for Japanese quail. The dichlobenil LD_{50} for honeybees was reported to be greater than 120.86 mg/bee (U.S. EPA 1998).

Metribuzin- Metribuzin is slightly toxic to mammals on an acute oral basis with toxicity values for laboratory rats at 2,200 mg/kg for females and 2,300 mg/kg for males and for laboratory mice 711 mg/kg for females and 698 mg/kg for males (U.S. EPA 1998a). Small herbivorous/insectivorous mammals are at acute high risk for broadcast application of nongranular metribuzin at application rates greater than or equal to 4.0 lbs a.i./acre. The levels of concern for endangered herbivorous/insectivorous mammals are exceeded for application rates greater than single applications of 1.0 lb a.i./acre or multiple applications of 0.5 lbs a.i./acre or greater. Chronic levels of concern for small mammals is exceeded at registered application rates equal to or above 0.5 lbs a.i./acre for broadcast applications of nongranular products.

Metribuzin is moderately toxic to birds on an acute oral basis and practically non-toxic to birds on a subacute basis. The LD_{50} for acute oral toxicity is 169.2 mg/kg (U.S. EPA 1998a) and for subacute dietary toxicity is >4,000 ppm for small birds and >5,000 ppm for large birds (U.S. EPA 1998a). Chronic effects in avian reproduction include a reduction in body weight at 14-days post hatch at all levels tested for Northern bobwhite quail, but not for mallard ducks (Hancock 1996). The NOEL and LOEC for Northern bobwhite quail is <62 ppm and for Mallard ducks is >368 ppm (Hancock 1996). Technical grade metribuzin is practically non-toxic to honeybees in acute contact scenarios. The LD_{50} for honeybees is 60.4 µg/bee (U.S. EPA 1998a).

Paraquat– There is a high risk for herbivores, small insectivorous mammals, and endangered large herbivorous and small insectivorous mammals from consumption of grass with herbicide residues. Applications with moderate concentrations of paraquat (1.0 lbs cation/acre) may produce residues on grass that result in high risk for small and medium herbivorous and small insectivorous mammals, restricted use medium insectivorous mammals, and endangered large herbivorous and small insectivorous mammals. At the highest application rate (1.6 lbs cation/acre) produces residues in grass that result in high risk for small and medium herbivorous and insectivorous mammals, restricted use levels of concern for large herbivorous mammals and endangered species levels of concern for large insectivorous mammals. Medium and high application rates of paraquat (1.0 and 1.6 lbs cation/acre) are high chronic risk for mammals (U.S. EPA 1997). The level of concern is exceeded for birds and presents high acute risk at application rates at or above 1.49, 0.60, and 0.3 lbs cation/acre. At application rates of 0.5 and 5 lbs cation/acre, paraquat can cause reduction of hatchability, significant mortality and reduced growth to mallard duck eggs (U.S. EPA 1997). Environmental fate data indicate that paraquat once applied and dried is not expected to pose a risk, and if washed off plant surfaces is very strongly adsorbed to clay particles. Therefore, the registered uses of paraquat are expected to reduce acute risks and are not expected to pose a chronic risk to mammals or birds.

Paraquat is relatively non-toxic to bees in dry crystalline and liquid formulations of technical and technical end-product paraquat dichloride, where contact LD50 ranged from 6.04->144 µg/bee (U.S. EPA 1997). There is a risk for honeybees when directly sprayed with high concentrations of paraquat dichloride CL.

Pendimethalin- Pendimethalin is slightly toxic to birds on an acute oral and subacute dietary basis, where LC_{50} values are 4,187 – 4,640 ppm (U.S. EPA 2003). No chronic bird reproduction studies have been completed for this chemical. Pendimethalin is slightly toxic to small mammals on an acute oral basis, which is based on a study that showed female rats had a LD_{50} of 1,050 mg/kg and male rats had a LD_{50} of 1,250 mg/kg (U.S. EPA 2003). Pendimethalin is practically non-toxic to honeybees on an acute contact basis, where the LD_{50} >49.7 µg/bee (U.S. EPA 2003).

Thifensulfuron methyl- Thifensulfuron methyl is practically nontoxic to mammals on an acute oral basis, where the LD_{50} is >5,000 mg/kg (U.S. EPA 2015). However, exposure through drinking water alone is a potential concern for acute toxicity in mammals and birds and chronic exposure in birds. Thifensulfuron methyl is slightly toxic for acute oral scenarios (LD50 >2,510 ppm for Mallard duck) and practically nontoxic for acute dietary scenarios in birds (LC_{50}>5,620 for both Bobwhite quail and Mallard duck. A slight reduction in the production of eggs and hatchlings was observed at a concentration of 1,250 ppm (U.S. EPA 2015). The NOEL is 250 ppm for Bobwhite quail. Upon acute direct contact with honeybees thifensulfuron methyl is practically nontoxic (LD_{50}>12.5 µg/bee) (U.S. EPA 2015).

Aquatic Species

Per the mitigation measures of the Navajo Nation Integrated Weed Management Plan, only aquatic formulations of herbicides are permitted within 25 feet of the daily high-water mark of any open water body. All herbicides have to be approved through the U.S. EPA registration process to evaluate human health and ecological risks. Product registration through the U.S. EPA requires only data that supports the FIFRA. The USFS and BLM have done independent risk assessments on the pesticides used on USFS and BLM lands to further evaluate the human health and ecologic risks associated with the herbicide. These risk assessments use published scientific literature, modeling and data collected for product registration to evaluate the potential for impacts on terrestrial wildlife from exposure to herbicides. There are difficulties in assessing possible risks because toxicity testing is often performed on laboratory animals, which may not be representative of free ranging wild animals or only a few wildlife species are tested.

Therefore, the risk assessments typically employ exposure estimates that yield conservative assessments of possible risks (Kendall et al. 2001).

Many of the herbicides proposed for use by the BIA on the Navajo Nation have been evaluated by the USFS or BLM and their toxicology data are included below. However, there are six herbicides proposed for use by the BIA that have only been evaluated for risk from toxicology data required by the USEPA's pesticide registration process. These herbicides include: dichlobenil, metribuzin, paraquat dichloride, pendimethalin, prodiamine, and thifensulfuron methyl.

Table K-2 shows the ecotoxicity categories for aquatic organisms as defined by the U.S. EPA. The aquatic animal toxicity endpoint for acute assessment includes the lowest tested EC_{50} (concentration of pesticide in water that causes immobilization in 50% of the test population) or LC_{50} (concentration of pesticide in water that causes lethality in 50% of the test population) for freshwater fish and invertebrates from acute toxicity tests.

Table K-2. Ecotoxicity Categories for Aquatic Organisms (from the U.S. EPA at http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm).

Hazard Indicators	Very Highly Toxic	Highly Toxic	Moderately Toxic	Slightly Toxic	Practically Non-Toxic
Acute concentration (mg/L)	<0.1	0.1-1	>1-10	>10-100	>100

This information is used to evaluate the potential risk of the six additional herbicides proposed for use under the Navajo Nation IWMP. The information provided below discusses their potential impacts to aquatic species. It is important to note that all are only approved for terrestrial use and would not be used within the 25 ft buffer surrounding open water sources.

Dichlobenil – Direct contact and ingestion data indicates that technical grade dichlobenil is moderately toxic to freshwater fish and slightly to moderately toxic to freshwater invertebrates. Its primary degradate 2,6 dichlorobenzamide (BAM) is practically nontoxic to freshwater fish and invertebrates. Tests of aquatic invertebrates conducted with a 50% formulation indicated that it is moderately toxic, with long term effects on reproduction for freshwater fish and invertebrates (Stavola and Turner 2003). BAM is only slightly toxic compared to its parent chemical, with long-term effects on fish but not invertebrates.

Metribuzin - Metribuzin and its degradates have the potential to contaminate ground water and surface water. However, the persistence of metribuzin in surface water may be reduced as it degrades when exposed to light (U.S. EPA 1998a). Laboratory studies indicate that technical grade metribuzin is slightly toxic or practically non-toxic to freshwater fish when directly exposed (Mayer and Ellerzieck 1986, U.S. EPA 1998a). There are no direct contact or ingestion levels of concern for freshwater fish and aquatic invertebrates at any registered application rate. Metribuzin is moderately toxic to slightly toxic to aquatic invertebrates at all exposure concentrations of active ingredient from direct contact (U.S. EPA 1998a). Reproduction was affected at all exposure levels.

Paraquat – Paraquat is very immobile in the soil as it strongly adsorbs to clay crystalline lattices. Therefore, it may be found in surface water associated with soil particles carried by erosion but is not likely to contaminate groundwater. It does not hydrolyze or photodegrade in water. Paraquat dichloride is slightly toxic to fish from direct contact (U.S. EPA 1997). Paraquat is moderately toxic to aquatic invertebrates.

Pendimethalin- Pendimethalin is moderately to highly toxic to fish based on toxicity studies evaluated by the U.S. EPA using maximum application rates (U.S. EPA 1997a). Long-term exposure to pendimethalin in fathead minnow resulted in reduced egg production (U.S. EPA 1997a). Technical grade pendimethalin was found to be highly toxic to freshwater invertebrates when directly ingested or contacted (U.S. EPA 1997a).

Prodiamine- Prodiamine is not water soluable and does not easily break down in water. Therefore, it would have high toxicity when directly ingested or contacted by freshwater fish and aquatic invertebrates (U.S. EPA 1991).

Thifensulfuron methyl- Thifensulfuron methyl is soluble in water, therefore there may be extensive movement into the soil column. Thifensulfuron methyl is practically nontoxic when directly ingested or contacted by fish and aquatic invertebrates (U.S. EPA 2015). This herbicide requires a 25 ft buffer.

Public Health

Health risks associated with herbicides depend on the toxicity of the herbicide being used, how a person is exposed to the herbicide, and the duration of their exposure. The public may be exposed to herbicide by contacting treated vegetation, consuming contaminated vegetation or water, or through herbicide drift. All alternatives would use herbicides and have the potential to expose workers or the public to herbicides. However, most exposures are not expected to exceed the daily exposure level determined as safe by the U.S. EPA for a 70-year lifetime of daily exposure.

Risk assessments quantify the potential risks for an herbicide based on label use and safety standards accepted by scientific experts. They evaluate potential hazards associated with the use of the herbicide based on their toxicity and the risk of exposure to hazardous doses for workers and the general public. These assessments assume workers and agencies comply with the product label during treatments. In addition to label instructions, the BIA plans to implement additional environmental protection measures for Alternatives 2 and 3 which further reduce potential risks to human health and the environment for herbicide treatments. These measures are detailed in the Mitigation Measures (Appendix F). It should be noted that federally and tribally certified pesticide applicators are required to supervise all herbicide applications for all proposed alternatives.

Risks for Proposed Herbicides

The risks of using herbicide depend on three main factors:

Method of Application – Herbicide applicators have a higher risk than the public of being exposed to harmful concentrations of herbicides. In comparing the risks to workers for all application methods, including aerial, backpack, ground mechanical, and hand applications, ground mechanical application (using a vehicle to apply herbicide) had the lowest risks compared to other methods, even though the total amount of herbicide applied is higher. Backpack and hand application have the highest risk, as workers are closer to the spray nozzle and carry containers of herbicides on their body. Backpack and hand applications also increase the likelihood of workers being repeatedly exposed to herbicides that may remain on their skin for an extended period.

Length of Exposure – Determining if a dose is harmful to an individual depends on whether a single dose is given all at once (acute), multiple doses are given over longer periods (chronic), or regularly repeated doses occur over an isolated period of time, which can range from several days to months (subchronic). The U.S. EPA requires manufacturers to evaluate chemicals based on these doses to determine potential risks for acute, chronic, and subchronic exposures. These doses are set below the amount that would cause toxic effects in humans, accounting for potential reactions from hypersensitive individuals while evaluating doses that workers or the public may be exposed to in real life. Many of these studies assume that the maximum duration of exposure for commercial applicators ranges from 10 to 40 days annually.

Route of Exposure – There are three main routes of chemical exposure: by ingestion (oral), through the skin (dermal), or by breathing it in (inhalation). The U.S. EPA requires toxicity testing for all substances for these mechanisms which is done through animal testing. Skin acts as a protective barrier that limits and slows down movement of a chemical into the body. In general, about 10% or less of a chemical can pass through the skin into the bloodstream. In contrast, absorption of a chemical from the small intestine is quicker and more complete than from the skin (Ross et al. 2000). For this reason, harmful dermal doses are usually much higher than oral doses. However, harmful effects can occur more quickly through inhalation than by oral or dermal contact, as the substance can rapidly enter the bloodstream. However, studies on pesticide applicators indicate they have a higher risk of dermal exposure as they occur more often than through inhalation or oral exposure (Ross et al. 2000).

Except for accidental exposures, workers and the public would not be exposed to herbicides at concentrations that would adversely affect public health. This conclusion is based on workers wearing appropriate PPE and applying herbicides according to label instructions. By doing so, the risk of harmful exposure would be low based on each herbicide’s toxicity. It also assumes that a person can be exposed to certain amount of a contaminant and not have an adverse effect (i.e. the dose determines the effect).

The following discussion examines the herbicides proposed under Alternative 2 that do not have associated risks assessments. Each of the herbicides is described based on their toxicity (LD_{50}), which is the concentration needed to kill over 50% of test animals when applied orally, dermally, or through inhalation (**Table K-3**). These ratings provide a relative measure of how harmful these chemicals are to humans.

Table K-3. Toxicity categories as defined by the USEPA. Pesticides are classified based on the dose needed to kill 50% of test animals. For humans, lethal doses (LD_{50}) are based on toxicity tests on rats.

Category	Equivalent Dose	Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)	Inhalation LD_{50} (mg/L)
IV - Not toxic	>1 pint	>5,000	>5,000	>2
III – Slightly Toxic	1 ounce to 1 pint	500-5,000	2,000-5,000	0.5-2
II – Moderately Toxic	1 teaspoon to 1 ounce	50-500	200-2,000	0.05-0.5
I – Highly Toxic	<1 teaspoon	<50	<200	<0.05

Dichlobenil –Dichlobenil can remain in the soil or on vegetation for two weeks to 6 months. The USEPA does classify it as a possible human carcinogen and it can cause liver and kidney damage at higher concentrations (U.S. EPA 2008). The herbicide can cause hormonal changes with prolonged exposure, which has led to further testing by the USEPA to examine its potential as an endocrine disrupter (U.S. EPA 1998, U.S. EPA 2009). Dichlobenil is classified as slightly toxic for oral and dermal exposures and not toxic for inhalation.

Metribuzin – Ecological risk assessments (EFSA 2006, U.S. EPA 1998a) indicate that metribuzin has a high risk of contaminating groundwater due to its weak adsorption to soil and its moderate half-life (ranging from 40 to 128 days). Based on animal studies (U.S. EPA 1998a), metribuzin can have adverse effects on liver function and reproduction at high doses. It can act as an endocrine disruptor and is not indicated as a carcinogen or a mutagen. Metribuzin has been classified as slightly toxic for oral and inhalation exposures and not toxic for dermal exposure.

Paraquat – Paraquat has the potential to contaminate surface water if contaminated soil is moved during erosion (U.S. EPA 1997). Animal studies indicate that paraquat can be toxic when ingested or inhaled (U.S. EPA 1997), resulting in adverse effects to the liver, kidneys, and lungs which can lead to death. Contact exposure to the eyes can cause moderate to severe irritation, while dermal exposure results in mild to moderate skin irritation. It is not indicated as a carcinogen but is a weak mutagen. Paraquat is classified as moderately toxic when taken orally, highly toxic when inhaled, and slightly toxic for dermal exposures.

Pendimethalin –It can bind strongly to soils, reducing its risk of contaminating groundwater or surface water through percolation or erosion. Pendimethalin is classified as a possible human carcinogen, which affects the thyroid (U.S. EPA 1997a). It can irritate the eyes and skin with direct contact. Pendimethalin is classified as slightly toxic for oral and dermal exposures and not toxic when inhaled.

Prodiamine –Prodiamine has a low risk of contaminating water sources as it has a short persistence in the environment and binds well to soils. Based on animal studies, prodiamine has adverse effects on the liver and thyroid (BPA 2000, U.S. EPA 1992). It is a carcinogen which has been tied to the development of thyroid tumors (Hurley 1998, COM 2001) and the liver (U.S. EPA 1992). It is shows fetal toxicity at high doses and developmental and maternal toxicity at low doses. It is slightly toxic when inhaled or applied to the skin. It is classified as not toxic for oral exposures.

Thifensulfuron methyl –Thifensulfuron carries a moderate risk of ground water and surface water contamination due to its weak affinity for soil particles. The risk is highest if rain or snowmelt creates runoff that impacts treated areas. Health risk evaluations (FAO 2011) indicate that thifensulfuron methyl is a mild eye irritant. It does not cause cancer, genetic damage, or birth defects and has little to no effect on fertility or reproduction. Thifensulfuron methyl is classified as not toxic for oral and inhaled exposures and slightly toxic for dermal exposures.

Metribuzin – Metribuzin impacts the thyroid at high doses. In rat studies, metribuzin decreased weight for the uterus and mammary glands in females and increased thyroid weight in males at high doses. Low doses resulted in changes to thyroid hormones that control growth, development, and metabolism. Studies indicate that metribuzin can reduce fetal body weight and interfere with bone development (U.S. EPA 1998a). EDSP Tier 1 screening indicated increased thyroid sizes with exposure to metribuzin and potential interactions with the thyroid (USEPA 2015b)

Impurities

Some of the herbicides proposed under the Navajo Nation IWMP can contain byproducts or impurities that are considered hazardous, making it important to limit the concentrations used to avoid potentially toxic exposures. Below various impurities associated with the proposed herbicides unique to the Navajo Nation IWMP discussed in detail, of which dichlobenil is the only with potentially hazardous metabolites.

Dichlobenil – A major metabolite of dichlobenil is 2,6-dichlorobenzamide (BAM), which leaves a residue on treated plants and poses a health risk to humans and animals. BAM has slightly greater toxicity than its parent compound and is classified as a possible human carcinogen with many of the same effects as dichlobenil (U.S. EPA 1998). However, the risk of adverse effects from exposure is considered low due to the low amounts measured in the environment after treatments (Björklund et al. 2011).

Inert Ingredients

The proprietary nature of herbicide formulations limits understanding the risks from inert ingredients (inerts) and adjuvants in herbicide formulations. Unless the compound is classified as hazardous by the USEPA, the manufacturer is not required to disclose its identity. It could be inferred that inert ingredients are not toxic, or their toxicity would be reported to the USEPA. While the USEPA has increased testing requirements for inerts, those currently in use have not been tested rigorously and their toxicity is not well characterized. Nonetheless, studies on the toxicity of technical grade formulations, which often contain inerts, accounts for their toxicity. These studies do not report human health concerns at the same level as herbicides. Analysis of inert ingredients is incorporated by reference (USFS 2005, BLM 2007, BLM 2016).

Surfactants

Surfactants are added to herbicides to improve mixing and absorption of the herbicide by the plant. Like dyes, there is limited information on surfactants and their toxicity, especially since the industry considers the surfactant to play a key role in the effectiveness of the herbicide. Most knowledge of surfactants is proprietary and not disclosed. The glyphosate risk assessment (SERA 2011), which provides some assessment of surfactants, reported that toxicity of glyphosate alone was the same as the toxicity of glyphosate + surfactant and greater than the toxicity of surfactants alone. Whether this same pattern would hold true of other herbicides with the same or different surfactants is unknown. If so, toxicological studies performed on herbicide formulations (which contain inerts and surfactants) may accurately portray the toxicity and risks posed to humans by the surfactant.

Endocrine Disruption

Recent studies raise concerns about the potential for some herbicides to interfere with hormone interactions. However, there is little evidence that herbicides considered for application would pose risks to the public at the recommended application rates based on the herbicide label instructions and the size of the area treated for any proposed alternative. The endocrine system regulates the production and release of hormones to manage a variety of bodily functions including growth, development, metabolism, and maturation. Endocrine glands (including pituitary, thyroid, adrenal, thymus, pancreas, ovaries, and testes) release measured amounts of hormones into the bloodstream that act as chemical messengers throughout the body to control many vital functions.

The U.S. EPA is required to develop tests to screen for chemicals with the potential to mimic hormones. Chemicals that mimic or antagonize hormones are called endocrine disrupting chemicals (Damstra et al. 2002) or hormonally active agents (HAAs). One concern over HAAs is due to how closely the endocrine system is linked to the brain and the immune system. All three systems communicate with one another to influence development and overall organ function. Adverse effects to this network can have a range of effects from cancer to infertility to behavioral problems (Felsot 2001).

Due to these concerns, the USEPA formed the Endocrine Disruptor Screening Program (EDSP). In 2009, the EDSP published screening protocols for 52 chemicals with the potential for endocrine disruption. Of the 52 chemicals, two herbicides proposed for approval under this action were found to have potential as endocrine disruptors (U.S. EPA 2015a, 2015b): dichlobenil, and metribuzin.

Dichlobenil – During a reregistration review of dichlobenil, the USEPA noted that new studies indicated that the herbicide could affect reproductive development (1998). The review looked at several animal studies and noted lower birth weights, increased maternal and fetal toxicity, and delayed maturation of the uterus. These effects were observed at both high and low doses. During the Tier 1 EDSP screening, dichlobenil showed evidence of androgen binding and decreased testosterone production (U.S. EPA 2015a).

Metribuzin – Metribuzin is known to impact the thyroid at high doses. In rat studies, metribuzin resulted in decreased weight for the uterus and mammary glands in females and increased thyroid weight in males at high doses. Low doses also resulted in changes to thyroxine and triiodothyronine, which help control growth, development, and metabolism. Developmental studies also indicate that metribuzin exposure can reduce fetal body weight and interfere with bone calcification (U.S. EPA 1998a). EDSP Tier 1 screening resulted in increased thyroid sizes for animals exposed to metribuzin, indicating interactions of the chemical with the thyroid pathway (U.S. EPA 2015b)

References

Björklund, E. B. Styrishave, G.G. Anskjær, M. Hansen, and B. Halling-Sørensen. 2011. Dichlobenil and 2,6-dichlorobenzamide (BAM) in the environment: what are the risks to humans and biota? *Science of the Total Environment*. 406(19): 3732-3739.

Bonneville Power Administration (BPA). 2000. Transmission System Vegetation Management Program Final Environmental Impact Statement. Portland Oregon.

Bonneville Power Administration (BPA). 2008. Dichlobenil Herbicide Fact Sheet. Available online at: Bonneville Power Administration (bpa.gov).

Communication from the Commission to the Council and the European Parliament (COM). 2001. Implementation of the Community Strategy for Endocrine Disruptors – a range of substances suspected of interfering with the hormone systems of humans and wildlife. Commission of the European Communities, Brussels. COM (2001) 262 Final.

Damstra, T., S. Barlow, A. Bergman, R. Kavlock, and G Van Der Kraak. 2002. Global Assessment of the State of Science of Endocrine Disruptors. World Health Organization. 180 p.

European Food Safety Authority (EFSA). 2006. Conclusion regarding the peer review of the pesticide risk assessment of the active substance: metribuzin. European Food Safety Authority Scientific Report (2006) 88:1-74.

Felsot, A. 2001. Assessing the safety of herbicides for vegetation management in the Missoula Valley region – A question and answer guide to human health issues. Food and Environmental Quality Laboratory. Washington State University, Richland, WA.

Food and Agriculture Organization of the United Nations (FAO). 2011. FAO Specifications and Evaluations for Agricultural Pesticides: Thifensulfuron methyl. 35p. Available online at: http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Specs/thifensulfuron-me_spec_eval_2011.pdf.

Hamel C., F. Morin, A. Fortin, R.L. Granger, and D.L. Smith. 1994. Mycorrhizal colonization increased herbicide toxicity in apple. *Journal of the American Society for Horticultural Science.* 119(2): 1255-1260.

Hancock, G. 1996. Effect of Technical SENCOR on Northern Bobwhite Reproduction: Lab Project Number: SE741701: 106984. Unpublished study prepared by Bayer Corp. 110 p.

Hurley, P.M. 1998. Mode of carcinogenic action of pesticides inducing thyroid follicular cell tumors in rodents. *Environmental Health Perspectives*. 106(8): 437-445.

Kendall, R., T. Anderson, R. Baker, C. Bens, J. Carr, L. Chiodo, G. Cobb III, R. Dickerson, K. Dixon, L. Frame, M. Hooper, C. Martin, S. McMurry, R. Patino, E. Smith and C. Theodorakis. 2001. Ecotoxicology. Pages 1013-1045 In C.D. Klaassen, ed. Casarett and Doull's Toxicology: The basic science of poisons. Sixth ed. McGraw-Hill Medical Publishing Division. NY.

Lee, E. H., C.A. Burdick, and D.M. Olszyk. 2005. GIS-based risk assessment of pesticide drift case study: Fresno County, California. Prepared for: Office of Pesticide Programs, Office of Prevention, Pesticides, and Toxic Substances, U.S. Environmental Protection Agency, Washington DC. 169 pp.

Mayer, F.L., Jr., and M.R. Ellersieck. 1986. Manual of acute toxicity: Interpretation and data base for 410 chemicals and 66 species of freshwater animals. U.S. Fish Wildl. Serv. Resour. Publ. 160. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

Pesticide Safety Directorate (PSD). 1991. Evaluation on: Thifensulfuron-methyl. Department for Environment, Food and Rural Affairs, Pesticides Safety Directorate (UK). Issue No. 39.

Ross, J., M. Dong and R. Krieger. 2000. Conservatism in pesticide exposure assessment. *Regulatory Toxicology and Pharmacology*. 31:53-58.

Stavola, A., and L. Turner. 2003. Dichlobenil analysis of risks to endangered and threatened pacific salmon and steelhead. Prepared for the U.S. Environmental Protection Agency, Office of Pesticide Programs, Environmental Field Branch. Pp. 33.

Syracuse Environmental Research Associates, Inc. (SERA). 2011. Glyphosate Human Health and Ecological Risk Assessment – Final Report. Prepared for the U.S. Department of Agriculture Forest Service, Forest Health Protection, Arlington, VA. Available online at: http://www.fs.fed.us/foresthealth/pesticide/pdfs/Glyphosate_SERA_TR-052-22-03b.pdf.

University of Hertfordshire. 2013. The Pesticide Properties DataBase (PPDB), developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire, 2006-2013. Available online at http://sitern.herts.ac.uk/aeru/ppdb/en/

USDI Bureau of Land Management (BLM). 2007. Vegetation Treatments on Bureau of Land Management Lands in 17 Western States and Final Programmatic Environmental Impact Report and Record of Decision. DOI/WO/GI-07/010+6711. Available online at http://www.blm.gov/wo/st/en/prog/more/veg_eis.html.

USDI Bureau of Land Management (BLM). 2016. Final Programmatic Environmental Impact Statement for Vegetation Treatments using Aminopyralid, Fluroxypyr, and Rimsulfuron on Bureau of Land Management Lands in 17 Western States. DOI-BLM-WO-WO2100-2012-0002-EIS. Available online at: http://www.blm.gov/wo/st/en/prog/more/vegeis.html.

U.S. Department of Health and Human Services, Public Health Service (USHHS) - Agency for Toxic Substances and Disease Registry. 2006. Interaction profile for: Atrazine, deethylatrazine, diazinon, nitrate, and simazine. Available online at: http://www.atsdr.cdc.gov/interactionprofiles/ip10.html.

U.S. Environmental Protection Agency (U.S. EPA). 1985. Metribuzin Pesticide Fact Sheet. Available online at: 91024KQ5.PDF (epa.gov).

U.S. Environmental Protection Agency (USEPA). 1991. Addendum to EEB risk assessment for prodiamine on turf and landscape ornamentals. D171612.

U.S. Environmental Protection Agency (USEPA). 1992. Prodiamine Pesticide Fact Sheet. Document 540/FS-92-175. 13 pp.

U.S. Environmental Protection Agency (USEPA). 1996. EFED Science Chapter for Pendimethalin. Prepared for the Office of Pesticide Programs, Environmental Fate and Effects Division. 47pp.

U.S. Environmental Protection Agency (USEPA). 1997. Paraquat Dichloride Reregistration Eligibility Decision. EPA 738-F-96-018. Available online at: http://www.epa.gov/oppsrrd1/REDs/0262red.pdf.

U.S. Environmental Protection Agency (USEPA). 1997a. Pendimethalin R.E.D. Factsheet. EPA 738-F-97-007. Available online at: http://www.epa.gov/oppsrrd1/REDs/factsheets/0187fact.pdf.

U.S. Environmental Protection Agency (USEPA). 1998. Dichlobenil Reregistration Eligibility Decision. EPA-738-R-98-003. Available online at: http://www.epa.gov/oppsrrd1/REDs/0263red.pdf.

U.S. Environmental Protection Agency (USEPA). 1998a. Metribuzin Reregistration Eligibility Decision. EPA 738-R-97-006. Available online at: http://www.epa.gov/oppsrrd1/REDs/0181red.pdf

U.S. Environmental Protection Agency (USEPA). 2000. Exposure and human health reassessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds : Chapter 8. dose-response modeling for 2,3,7,8-TCDD : Part II: health assessment for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds. EPA/600/P-00/001. Washington, DC. OLS listing online at https://cfpub.epa.gov/ncea/iris_drafts/dioxin/nas-review/index.cfm#part2.

U.S. Environmental Protection Agency (USEPA). 2003. Registration eligibility decision (RED) Pendimethalin. Environmental Fate and Effects Division (Case # 0817).

U.S. Environmental Protection Agency (USEPA). 2008. Dichlobenil; Pesticide Tolerances, Final Rule. Federal Register. August 27, 2008. 73(167): 50563-50570.

U.S. Environmental Protection Agency (USEPA). 2009. Final list of initial pesticide active ingredients and pesticide inert ingredients to be screened under the Federal Food, Drug, and Cosmetic Act. *Federal Register,* 74(71): 17579-17585.

U.S. Environmental Protection Agency (USEPA). 2011. Ecological risk assessment problem formulation for: Thifensulfuron methyl.

U.S. Environmental Protection Agency (U.S. EPA). 2015. Preliminary Ecological Risk Assessment for Registration Review of 22 Sulfonylurea Herbicides. Published August 2015. 318 p.

U.S. Environmental Protection Agency (USEPA). 2015a. EDSP: Weight of evidence analysis of potential interaction with estrogen, androgen, and thyroid pathways. Chemical: Dichlobenil. Published June 29, 2015. TXR No. 0057167. Available online: http://www2.epa.gov/ingredients-used-pesticide-products/weight-evidence-edsp-diclobenil.

U.S. Environmental Protection Agency (USEPA). 2015b. EDSP: Weight of evidence analysis of potential interaction with estrogen, androgen, and thyroid pathways. Chemical: Metribuzin. Published June 29, 2015. TXR No. 0057184. Available online: http://www2.epa.gov/ingredients-used-pesticide-products/weight-evidence-edsp-metribuzin.

U.S. Environmental Protection Agency (U.S. EPA). 2019a. Paraquat: Preliminary Ecological Risk Assessment for Registration Review. Published June 26, 2019. USEPA PC Code 061601. 180 p.

U.S. Forest Service (USFS). 2005. Final Environmental Impact Statement for the Integrated Treatment of Noxious or Invasive Weeds: Coconino, Kaibab, and Prescott National Forests within Coconino, Gila, Mojave, and Yavapai Counties, Arizona.

U.S. Geological Survey (USGS). 1999. The Quality of Our Nations Waters: Nutrients and Pesticides. U.S. Geological Survey Circular 1225. 82p.