Ecological Integrated Pest Management Program

Operations Manual

I. IPM Guidelines and Pesticide Assessment Process

Overview

What is Integrated Pest Management (IPM)?

Ecological Integrated Pest Management uses adaptative management with an ecosystems management approach to promote ecological resilience and protect ecosystem services. Rather than focusing on the management of individual species or pests, the community of interacting organisms and populations are managed for ecosystem stability to protect overall biodiversity and ecosystem health.

The city defines IPM as a decision-making process that selects, integrates, and implements a combination of suitable and compatible strategies to prevent, deter, or manage pest populations within established thresholds. IPM uses a "whole systems approach," viewing the target species as it relates to the entire ecosystem. Management strategies are chosen that minimize impacts to human health, the environment, and non-target organisms.

Who is required to follow the city's IPM policy?

All city staff, including seasonal staff, contractors and lessees are required to follow the city's IPM Policy and the guidelines in this manual on all city-owned properties.

What types of activities are included?

The city's IPM policy provides guidelines for the implementation of the most environmentally sound approaches for landscape, natural area, agricultural and facilities management. This includes all monitoring, non-chemical pest management practices and any pesticide use in buildings and related facilities, grounds, open space, and all other property owned or managed by the City of Boulder.

Quick Links:

City of Boulder IPM Policy
Approved Pesticide List
IPM Factsheet

I. The History of IPM

Integrated Pest Management or IPM manages ecosystems for long-term pest prevention. When ecosystems are in ecological balance, the different organisms living in an ecosystem are relatively stable over time. Ecosystems can become imbalanced from external stressors, both natural and anthropogenic, including the introduction of new species, the loss of native organisms, habitat destruction or fragmentation, pollutants including pesticides, and climate change. When ecosystems are out of balance, organisms can become pests. The goal of IPM is to manage systems in a way that maintains as much ecological balance and resilience as possible to prevent pests.

The modern concept of IPM was first developed in response to the problems that arose from the significant expansion of synthetic pesticide use during the 20th Century, particularly post-World War II. Between 1951 and 1979, synthetic pesticide production in the U.S. increased from half a million pounds to 1.4 billion pounds. New pesticides like DDT and 2,4-D were so effective at killing pests that they were used in multiple settings, from homes to agricultural fields. The availability of pesticides on a large scale also allowed people to use practices like agricultural monoculture and exotic urban plantings, which creates an environment that can lead to pest issues.

Although few people saw any downsides at the time, unintended ecological consequences became apparent by the late 1940's. Agricultural yields were also impacted when pest populations exploded due to resistance and/or from the poisoning of pest predators and natural enemies. Secondary pests also became major issues – organisms that had previously not been a problem increased unchecked after their natural enemies disappeared due to these new potent pesticides. When Rachel Carson's "Silent Spring" was published in 1962, the public and the government became aware of the issue, and learned that DDT was contaminating the entire food chain, resulting in catastrophic environmental problems and threatening birds and other animals with extinction.

In response, a group of entomology professors developed IPM methods in the late 1950's to reverse the damage caused by the widespread use of pesticides by restoring the natural function of the food web and rebalancing biodiversity by ecologically-friendly practices. In the IPM decision process, pesticides are only considered after a pest reaches a "threshold," where natural factors aren't sufficient to keep pests in check and damage from the pest causes economic losses. IPM demonstrated that when ecological principles are used to prevent pest problems, such as crop rotation, building healthy soils, and providing floral resources for pollinators and natural predators, that pesticide intervention is often unnecessary.

IPM in Boulder

Boulder has a long history of environmental stewardship and a legacy of protecting its land and resources for future generations by forward-thinking, scientifically based and cutting-edge approaches.

Boulder's IPM program was developed in the late 1980's and the city's first IPM policy was adopted in 1993 based on the principles that were developed by the scientists who pioneered IPM in the 1950's. IPM is a dynamic, decision-making process that is based on the best available science, and relies on observation and knowledge of the target organism and the ecosystem where it lives.

The current IPM policy was updated in 2019. The city defines IPM as:

> *a decision-making process that selects, integrates, and implements a combination of suitable and compatible strategies to prevent, deter, or manage pest populations within established thresholds. IPM uses a "whole systems approach," viewing the target species as it relates to the entire ecosystem. Management strategies are chosen that minimize impacts to human health, the environment, and non-target organisms, and protect overall biodiversity and ecosystem health.*

Relevance of IPM Today and Continuing Impacts from Pesticides

When the unintended and devastating consequences of DDT became undeniable, it was banned in 1972. However, people had become reliant on chemical inputs and new pesticides were developed to replace DDT. As new families of pesticides were released, they were considered improvements over the previous generation of products. Yet familiar problems like pest resistance or unintended ecosystem impacts arose again with each family of pesticides. Using insecticides as an example—the organophosphates, carbamates, pyrethroids, and more recently, the neonicotinoids—have all been touted as safer than previous generations of pesticides. However, when each of these groups of pesticides were released, they were used extensively with the assumption that these newer products wouldn't result in the same issues as previous products. The cycle of moving to one pesticide group from another is known as the "pesticide treadmill." More than six decades since IPM was first developed, global pesticide use continues to increase and is currently 2 million tons and climbing.

Relying on a product or a pesticide to target the pest instead of focusing on and addressing the underlying cause of the problem is not only likely to fail over time, but often creates new problems. Using ecological principles and a systems approach to pest management provides long-term, reliable management of pests. Although many practitioners and land managers aspire to implement IPM practices with good intentions, a reliance on pesticides has undermined many foundational IPM ecological principles contributed to human health issues and broad ecological harm.

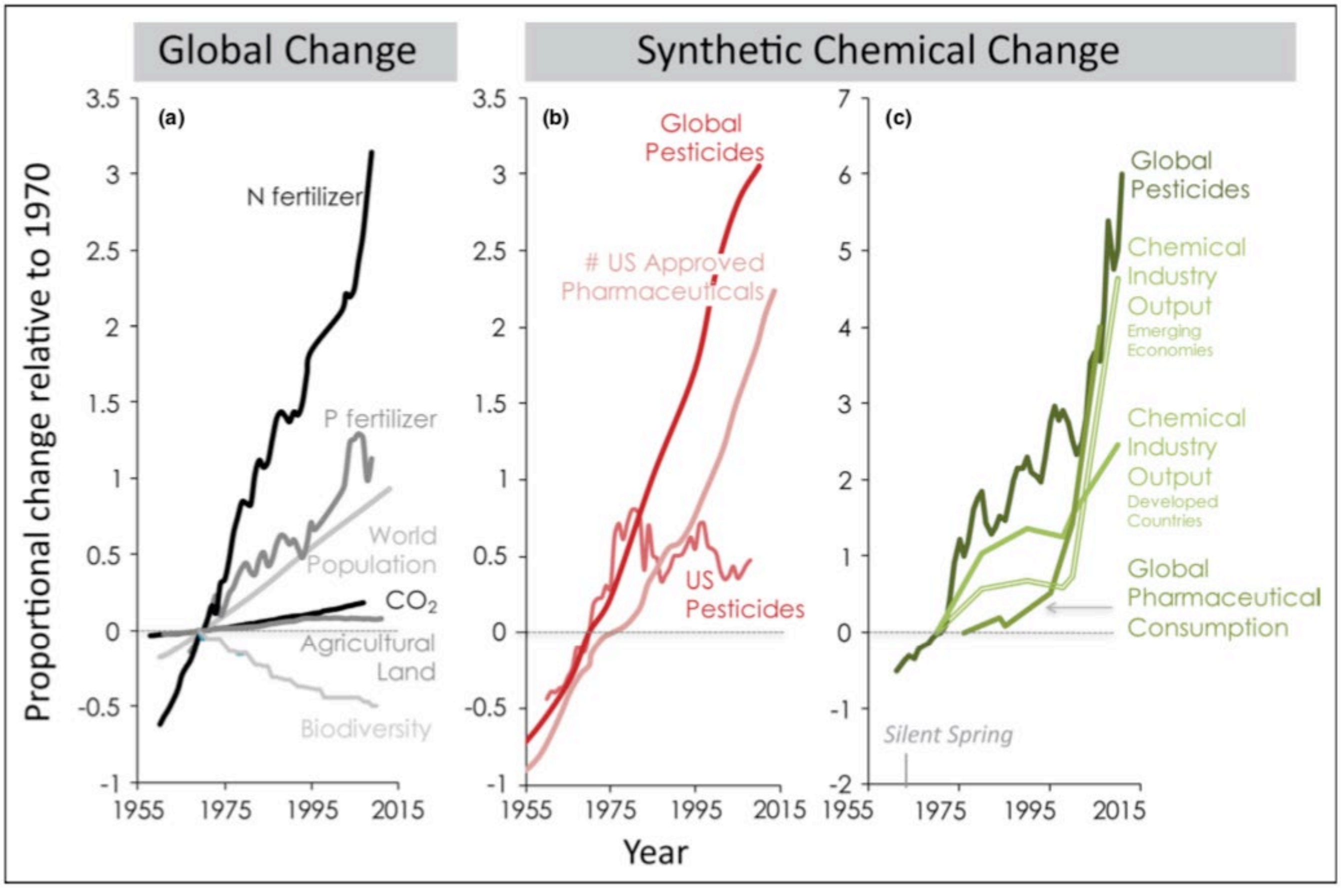
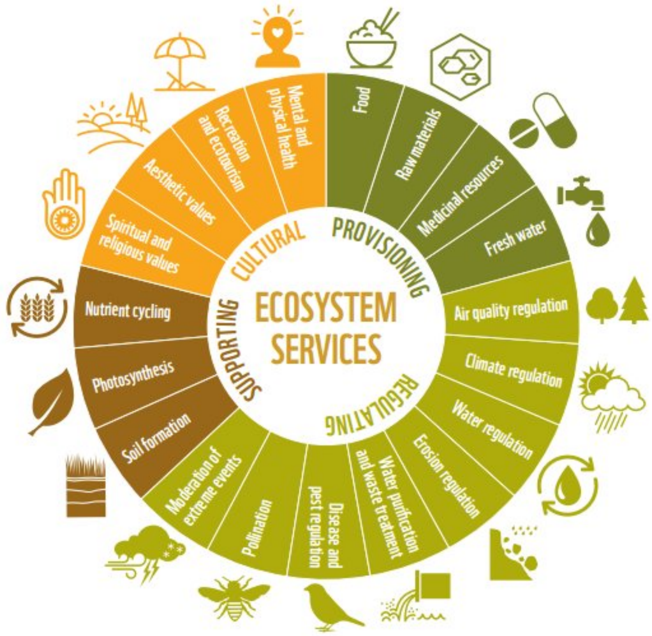


Figure taken from Bernhardt et al., 2017. Supporting data sources.

Pesticide contamination is found throughout the earth from the artic to the oceans. In fact, DDT is still causing harm to lake ecosystems 50 years after it was banned and is still found in our bodies along with other chemicals and banned pesticides. These chemical stressors in combination with habitat loss from expanding agriculture, urbanization, mineral and fossil fuel extraction, other human-based activities, and climate change have led to extensive losses of biodiversity. The 2016 Living Plant Report from the World Wildlife Federation shows that between 1970 and 2012, 58 percent of mammals, birds and fish populations were lost, with the biggest decline in freshwater species, which dropped by 81 percent.

In addition to the precipitous decline of pollinators, all other insects around the world are in steep decline. The current rate that species are undergoing extinction is altering the planet, the consequences of which are not yet understood. A diversity of organisms is crucial for functioning ecosystems. All life on the planet is sustained by the "ecosystem services" that healthy ecosystems provide, such as food and fiber, clean air and water, and climate regulation.



(©Peter Burgess, True Value Metrics)

Ecologically Based IPM is Crucial to Sustain Ecosystem Services and Address Climate Change
With changing climate, there are winners and losers among the different species that make up ecosystems. Some species will adapt and remain, some will migrate to new locations and some will go locally extinct. The invasion of exotic and invasive species compromises these already stressed systems and may alter or degrade ecosystem services. A thoughtful and cautious approach is necessary for managing invasive species without inadvertently causing more harm to desirable organisms and their interactions with other species of the ecosystem community. Properly implemented IPM is crucial to adapting to climate change— diverse, highly-functioning ecosystems serve in providing resilience from the unpredictable conditions of extreme weather and natural disasters that are expected to increase as a result of global warming. Ecosystems also sequester carbon and are a critical element in efforts to mitigate and lower greenhouse gases. A recent study suggests that the world's wetlands, forests and grasslands could provide up to a third of the carbon sequestration required to keep global temperature rise within 2°C by 2030. Therefore, protection of ecosystems and the creation of high-quality habitat by ecologically based IPM practices is crucial for a comprehensive and successful climate action plan.

The role of urban ecosystems is often overlooked. Urban ecosystem habitats within cities are now recognized to be increasingly important in supporting populations of plants and wildlife, as well as providing corridors for migrating species and even in sequestering carbon. Boulder is one of pioneering cities leading the movement to improve urban landscaping and infrastructure in ways that optimize carbon drawdown. IPM is an important part of this work.

II. The IPM Process

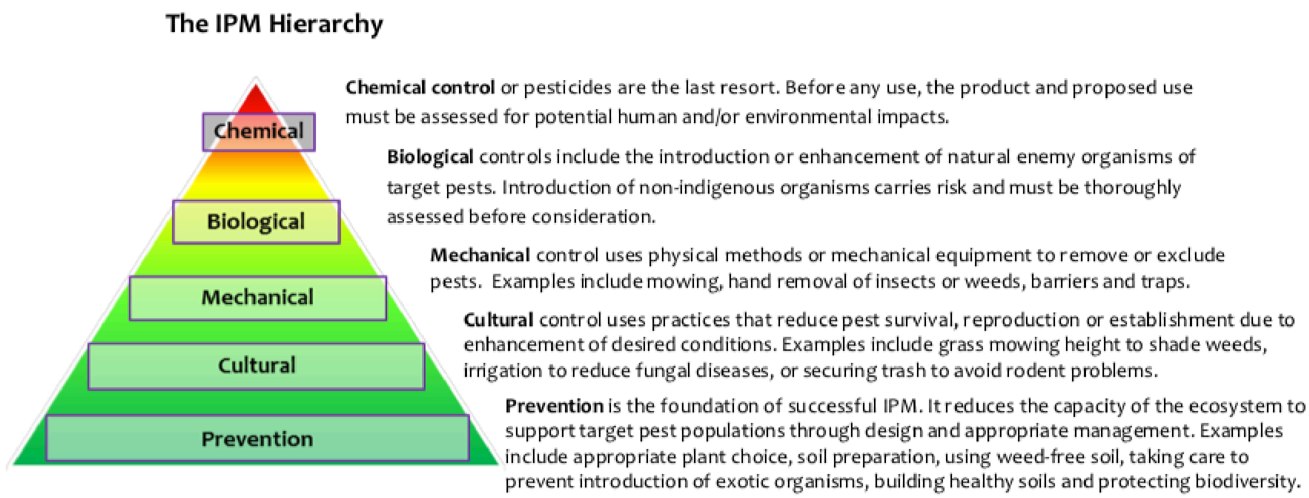
IPM uses a common-sense approach to decision-making, based on the best available science, observation and a knowledge of the biology of the target organism, which is viewed within the context of the functioning ecosystem where it lives. It is a "whole systems approach," which selects, integrates, and implements a combination of strategies to prevent or manage pest populations within established thresholds. An important aspect of IPM is how the “target organism” or “pest” is viewed. A pest (e.g. insect, weed, rodent, nematode, fungus, etc.) is an organism that interferes with or reduces the availability or quality of desirable plants and other resources, impacts human or animal health, damages structures or harms some component of the ecosystem. Whether or not an organism should be considered as a pest depends on where it’s geographically located and/or the setting, rather than the particular species.

When choosing management strategies, consider the potential impacts to human health, the environment, non-target organisms, and overall biodiversity and ecosystem health of the site. Successful management is tailored to each site. The strategies that are chosen should augment or restore natural checks and balances within the ecosystem or food web; with rare exceptions, the goal is not to eliminate the pest species, but to suppress or decrease its population to the point that environmental factors and natural enemies keep it within tolerable limits. Therefore, an important aspect of IPM is to develop specific criteria about the density of the pest or the damage caused by the pest and ensure that it reaches a threshold before action is taken to manage it. In some cases, such as noxious weeds, the state determines the threshold. But in most cases, the thresholds will be developed based on best management practices (BMPs) and staff knowledge and experience with specific sites.

The development of thresholds will be addressed in individual sections of this manual with guidelines for the different areas of land management.

How are IPM strategies chosen?
Options are chosen and assessed by reviewing information about each site and the pest threshold. Prevention is the foundation of IPM and many problems can be avoided by proper site management, decontaminating equipment and not introducing potential pests to an area in materials such as seed or soil. Management practices should be categorized and placed within the hierarchy (see below) and prioritized from the least impactful and most ecologically compatible to the most impactful options that carry the most potential risk of harm or can interfere with other management objectives or ecosystem balance. This can become quite complex and can require continuous gathering of information and may need the development of new site-specific approaches.

Often, a combination of approaches is necessary. Many times, the most environmentally sound management practices on the lower tiers of the hierarchy pyramid keep pest populations within acceptable levels and pesticides are rarely if ever needed. When non-chemical approaches fail or are not feasible, then judicious use of pesticides is considered.



[As specific land management chapters are developed, links to them will be placed here]

III. The Pesticide Assessment Process

Background

Before any pesticide is considered for application on any property managed by the City of Boulder, it must first be assessed. In this process, additional restrictions may include the target pest, where and when the pesticide can be used, and the application method. The more hazardous the pesticide and the more potential risk, the more restrictions are in place in order to minimize unintended effects to people, non-target organisms, surface and ground water and overall environmental health.

The city's IPM policy states that "the city assumes that all pesticides are *potentially* hazardous to human and environmental health" with the goal "to reduce and eliminate, where possible." Why? And why does the city require additional screening and prohibit the use of the majority of pesticide products? Pesticides are different from all other chemicals in that they are *designed* to kill or repel a living organism. In the majority of pesticide applications, only a small amount of the pesticide actually reaches the target pest, with most of it ending up in the air, water or soil where non-target organisms are inadvertently exposed.

A recent study showed that the variety and quantity of pesticides applied globally continues to increase at a steep rate and is one the most significant drivers of global environmental change. Yet, very little is known about the impacts of these products on ecosystems and the environment—this area is virtually ignored in research and receives no extramural research funding from the EPA. Less than 1% of ecological journal articles, 1.3% of the presentations at conferences, and 0.01% of the National Science Foundation grants explore the environmental effects of these chemicals.

It's not just environmental problems that arise from pesticide application. Compelling evidence demonstrates a statistical association between diseases in humans and pesticides including cancer, asthma, diabetes, Parkinson's disease, leukemia, cognitive disorders and other health problems. Some individuals or populations, such as pregnant women, children and older people are more susceptible to pesticide-associated diseases and reproductive effects. This is compounded by the fact that people are exposed to mixtures of chemicals with little known about the effects, particularly over time.

EPA Pesticide Registration

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires registration of all pesticides before they are sold or distributed in the U.S. under a one-size-fits-all standard setting process. The federal government adopts pesticide registration and application standards based on determinations of acceptable levels of risk and exposure, as well as benefits, including economic benefits. Pesticides can be registered even if they pose hazards to humans and the environment as long as EPA administrators determine that the benefits outweigh the hazards.

Pesticide companies or registrants must submit the results from a standardized set of tests using specific organisms to represent human health risks, studies to determine risk to non-target organisms, pesticide drift evaluation and environmental fate, which includes studies that look at the distribution and persistence of pesticides in soils and water.

Acute Toxicity

Acute toxicity reflects the hazard of a one-time or short-term exposure that results in an effect that happens either immediately or within minutes to hours. The EPA measures acute toxicity through the different exposure routes that pesticides can enter the body, which include:

- Oral toxicity – effect from ingesting a pesticide or accidentally getting it in the mouth
- Dermal toxicity – effects from absorbing a pesticide through the skin. This is the most common route of exposure, particularly for people handling pesticides and may go unnoticed.
- Inhalation toxicity – effects from breathing pesticide vapor, dust or spray particles
- Eye irritation – effects from pesticide getting into the eyes
- Primary dermal irritation – pesticide exposure to skin that causes reversable skin damage
- Dermal sensitization – pesticide exposure to skin that causes allergic reaction

Test animals are subjected to a range of doses of a pesticide until the LD50 or LC50 is reached – this is the either the dose (LD50) or the concentration (LC50) of pesticide that kills 50% of the test animals. If a product is very low in toxicity, these values will be extrapolated. The smaller the LD50 value, the more acutely toxic the pesticide. This may be counterintuitive, but LD50 is the amount of pesticide per kg of weight of the animal. So, the larger the quantity of pesticide that the animals were fed before the dose was high enough to kill them, the higher the LD50.

The toxicity categories (I-IV) and signal words (Caution, Warning and Danger Poison) found on pesticide labels are based on **acute toxicity** or the immediate hazards from being exposed to a pesticide through these different exposure routes. It does not reflect the effects from long-term or "chronic" exposure. This is an important distinction since long-term exposure through undetected routes like skin absorption can result in serious health consequences down the line.

A compound can be high in an EPA category (low hazard), but have minimal risk for low-dose, long-term exposure. For example, caffeine has an oral LD50 of 150-200 m/kg, which would designate it as a Category II or label signal word "Warning," but has very little risk for long-term exposure. Another example is horticultural vinegar, which has the signal word, "Danger," because it's extremely corrosive, placing it in the highest acute toxicity category, but long-term exposure to table vinegar has no known health effects.

Conversely, a compound can be in a low toxicity EPA category, yet potentially have significant health risks. For example, a pyrethroid insecticide can be Category III/Caution, yet be associated with cognitive issues in children and reproductive issues in men, or the herbicide atrazine, also a Category III/Caution, has been associated with reproductive issues in humans and animals at tiny doses. Do not be complacent about the health risks of EPA Category and III and IV pesticides and their potential impacts to non-target organisms and the environment.

Routes of Exposure	Toxicity Category			
	I	II	III	IV
Oral LD_{50}	Up to and including 50 mg/kg	50-500 mg/kg	500-5,000 mg/kg	>5,000 mg/kg
Inhalation LC_{50}	Up to and including 0.2 mg/l	0.2-2 mg/l	2-20 mg/l	>20 mg/l
Dermal LD_{50}	Up to and including 200 mg/kg	200-2,000 mg/kg	2,000-20,000 mg/kg	>20,000 mg/kg
Eye Effects	Corrosive corneal opacity not reversible within 7 days	Corneal opacity reversible within 7 days; irritation persisting for 7 days	No corneal opacity; irritation reversible within 7 days	No irritation
Skin Effects	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours
Signal Word	DANGER POISON	WARNING	CAUTION	CAUTION
Adapted from 40 CFR Part 156.				

Figure from PennState Extension.

Chronic Toxicity

The EPA conducts other tests using mainly feeding studies to determine the effects of long-term, repeated exposure on test organisms. Health conditions are assessed such as cancer, impacts to the nervous system or to genes, hormonal disruption, tumors, blood disorders, organ damage and other health issues. Multi-generation studies can measure impacts to progeny, including survival, weight and birth defects.

Environmental Fate

Each chemical behaves differently in the environment. Some products are water soluble and can leach into surface or ground water, while others adhere tightly to organic matter in the soil or sediment in bodies of water. Some chemicals break down relatively quickly and others can persist for years or even decades. Pesticides can accumulate up food chains or be rapidly excreted from animals. Different products have different stabilities in sunlight, water or to micro-organisms or within a plant or animal. The EPA requires testing to determine these properties.

The Pesticide Label – the "Label is the Law"

The pesticide label is a ***legally binding*** document that all users are required to read and follow. Violation of any directions on the label is a federal offense. After the pesticide undergoes required testing, the EPA must approve all language on the label before it can be sold and distributed. This language includes information about the active ingredients, directions for application rates, mixing and handling, personal protection for the applicator, reentry intervals, target pests and restrictions for use. Colorado state law requires anyone working for a public entity, including cities, to undergo basic applicator training. Your supervisor will either provide this training and/or refer you to an online module before you are permitted to apply a pesticide. Learn more about the pesticide label.

Deficiencies in the EPA Pesticide Registration Process

Risk assessment is a complicated process and it is incredibly difficult to ascertain the actual risks and impacts from synthetic chemicals on either human health or the environment. There are approximately 1700 chemicals that are registered by the EPA as pesticide active ingredients. There are many thousands of formulated products that consist of either a single active ingredient or mixtures of active ingredients. In addition, "inert" ingredients are in the majority of formulations and adjuvants can be added during mixing. In most cases, inert ingredients are not disclosed and considered proprietary by the pesticide manufacturers.

Major weaknesses with the EPA's testing requirements are:

1. **Lack of independent data**
   When a new active ingredient is developed, there are no independent studies available. The only toxicity or environmental fate data available are studies submitted by the company. These studies are not peer-reviewed by scientists or even available for scrutiny. In the majority of cases, these studies are considered confidential business information. The use of only industry-generated data has an inherent conflict of interest.
   - Once a product in on the market, most funding for pesticide research goes for efficacy trails, not human health or environmental impacts. Unless a product becomes controversial, little

independent research will likely occur, leaving many questions about safety unresolved. Products are only evaluated every 15 years during re-registration. At that time, the EPA's narrow criteria can exclude the majority of available independent research.

- The EPA may call Scientific Advisory Panels (SAP), but the EPA can disregard the SAP's advice in final decisions. For example, at least two scientists from the SAP that evaluated glyphosate as a carcinogen disagreed with the EPAs conclusion that glyphosate is not a probable carcinogen; these scientists published a review paper with convincing evidence that glyphosate is in fact a probable carcinogen.

2. **Loopholes allow incomplete testing before or after pesticides are on the market**
   - Required studies are often not completed. When FIFRA is updated, it often results in backlogs of already-registered chemicals that have never completed current testing requirements.
   - Chronic toxicity for non-agricultural pesticides can be and are often waived.
   - During the conditional registration process, other tests are waived. Conditional registration was meant to be rarely used, but it has become a loophole to get products on the market without full testing requirements being completed.

3. **Testing on single chemical.** The EPA usually tests individual active ingredients alone for health and ecological testing, instead of the formulated product that can contain mixtures of active ingredients and other, usually undisclosed, co-formulant chemicals. There are around 3000 of these chemicals in pesticide formulations.

   "Inert" or co-formulant ingredient unaccounted risks

   - The majority of products do not disclose the identity of co-formulants, claiming they are trade secrets or propriety. These products can make up the majority of pesticide formulations (average of 86%) and may have chemical or biological activity on their own. In the cases where they are disclosed, such as POEA (Polyethoxylated tallow amine) in Roundup (glyphosate formulation) or naphthalene, which is commonly used in many herbicides, these products have toxic properties on their own. At least 50% are considered toxic or moderately toxic.
   - Inert ingredients and solvents in formulated products can increase pesticide exposure to applicators by reducing the protective qualities of clothing and gloves. They can make washing clothing less effective at removing pesticides.
   - Inert ingredients can alter and increase the toxicity of the pesticide to people and to non-target organisms.

4. **Synergistic or additive effects of multiple ingredients**
   Not only do inert ingredients affect the overall toxicity of the pesticide formulation, but mixtures of more than one active ingredient can significantly increase toxicity. In fact, a recent analysis

showed that pesticide companies often **patent** active ingredients as synergists to other pesticide chemicals. During the six-year period of this analysis, 96 of 140 products approved by the EPA had at least one patent that claimed synergy between active ingredients. This can have serious implications that the EPA completely ignores. For example, studies have shown that a common fungicide boosts the toxicity of neonicotinoid insecticides to bees.

5. **Pesticides with known problems can take decades to get off the market.**
   Once there is significant evidence that a problematic chemical needs to come off the market, it can take years for it to be removed. When the Food Quality Protection Act passed in 1996, the EPA was required to look at the cumulative health effects of groups or families of pesticides with similar modes of actions and chemistries as a "risk cup." A priority was to phase out organophosphate and carbamate insecticides, but new registration of these products continues.

   The U.S. registers and allows millions of pounds of pesticides that are banned in Europe, China and Brazil to be applied each year.

6. **The ecological impacts of pesticides are not understood**
   Pesticides, mixtures of pesticides and other synthetic chemicals are present in every ecosystem on earth from terrestrial, to fresh water to marine. These impacts are not well studied and very little is known about how existing contamination and continued pesticide use will affect the planet long-term. The figure below illustrates the levels of complexity from direct types of toxicity to individual organisms, populations, communities and ecosystems. See the full study for more information about the patterns of pesticide use, what is known about ecosystem impacts and how it interacts with climate change.

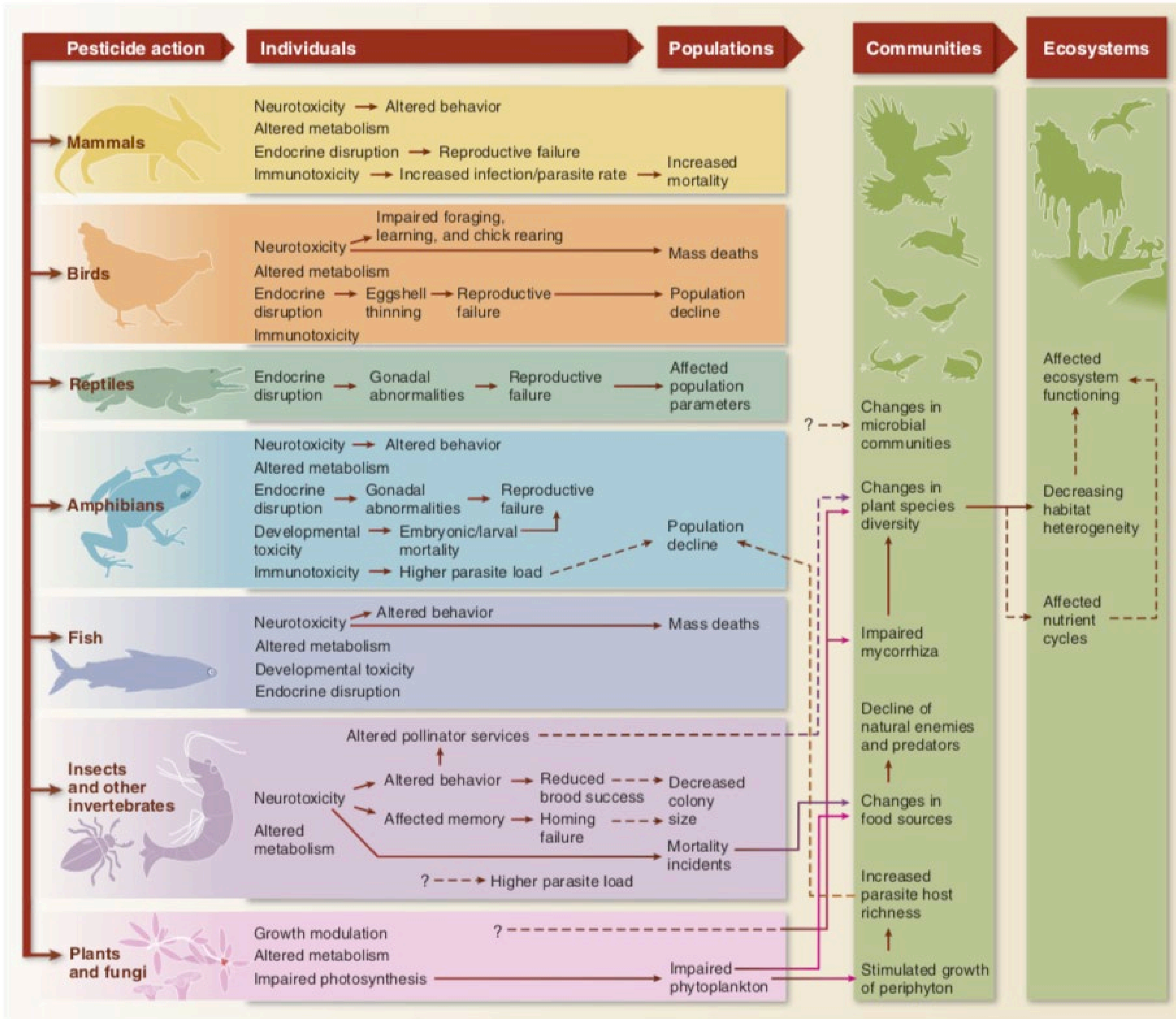


Fig. 2. Documented pesticide effects on wildlife at different levels of biological organization and known (solid arrows) or evidence-supported, anticipated (dashed arrows) interrelations among them. Research remains to be conducted wherever plausibly interrelated effects are not connected by arrows. Most of the sub-individual data for mammals are derived from non-wildlife studies.

www.sciencemag.org SCIENCE VOL 341 16 AUGUST 2013

The Precautionary Principle

With incomplete and insufficient information to establish the actual risks and harms to human health, ecosystem stability and climate change, the most responsible approach is to avoid the application of these products as much as possible. This is why the city does not assume that a pesticide that is registered by the EPA is safe, conducts additional screening and restricts how and where pesticide products can be used.

The Approved Pesticide List Process

A pesticide can only be used on city property if it is on the city's approved pesticide list – a prescreened list of pesticides that are organized into tiers or categories of hazard or risk based on clear criteria. There are three well-developed models for tiered lists that city used to develop its system. The first list was developed for Seattle and adopted and revised by San Francisco. Santa Clara County, California also has a well-defined process and list that was developed by a professor from Cornell University. Thurston County, Washington has a rigorous, transparent process with tiered pesticide categories that was developed and is maintained by experts in its health department.

The criteria for evaluation and the assessment of pesticides provides staff and the public with a clear and transparent understanding of what each category means and restricts the application of each pesticide to public properties based on the risk assessment and hazard tier.

Pesticides are categorized as:

1. **Allowed** – these are the least hazardous pesticides. Staff are authorized to use these products as they see fit within the parameters of the IPM process.
2. **Conditional** – these products are limited to specific sites/and or pests and application methods.
3. **Special Use** – this is the most hazardous pesticide category. There must be no available effective non-chemical method or alternative product in lower tiers. Staff are required to decrease exposure potential as much as possible to the applicator, the public, non-target organisms and the environment and the pest must exceed a threshold **and** pose specific hazard/cost that outweighs risks from the pesticide. There must be an ongoing search for less hazardous products or non-chemical alternatives.

The following information is used to determine the hazard/risk of a pesticide.

Acute Toxicity: This is a single dose or short exposure from ingestion, inhalation or dermal exposure of a pesticide.

Chronic Toxicity: This is repeated exposures that occur over long periods of time. Some tests look for health issues in single individuals such as cancer, nerve system damage and other health effects, while others look at reproductive issues that are passed on to progeny. This includes "sublethal" effects, where the exposure doesn't kill the animals, but can cause other health issues over its life.

Endocrine Disruption: Some chemicals can mimic or interfere with the body's hormonal systems. This can happen at very low doses can cause reproductive problems, birth defects, cancer and developmental issues. The term is often used in risk assessment that the “dose makes the poison,” which may be true for acute toxicity. For endocrine disruption, miniscule doses can cause major impacts during developmental windows of embryos and fetuses or in long-term exposure in children and adults.

Environmental Fate: These studies look at how the pesticide acts in the soil, water, air and how it breaks down and interacts with other factors in the environment. These studies measure persistence in the soil and water, volatility, ability to leech and other factors.

Ecological Toxicity: A whole range of studies, both regulatory and independent research, examine the effects of pesticides on non- target organisms from micro-organisms to mammals. These can be direct effects or indirect effects, such as a bird or fish being impacted from a pesticide killing the insects they rely on for food.

The chart below summarizes the criteria for the city’s hazard tiers.

City of Boulder – Hazard Tier Criteria for Approved Pesticide List

Allowed – Least hazardous *Staff-level decision to use within parameters of IPM process**	**Conditional** – More hazardous *Use limited to specific sites and/or pests and only by approved application method**	**Special Use** – Most hazardous *Must be **no** available effective non-chemical method or alternative products in lower tiers. Decrease exposure potential as much as possible to applicator, the public, non-target organisms and the environment. Pest must exceed threshold **and** pose specific hazard/cost that outweighs risks from pesticide. **Requires ongoing search for less hazardous alternative or replacement****	**Failed** – Not allowed *Current hazard assessment and potential exposure to people or the environment is too high risk for use on city properties.*
• Active and inert ingredients meet criteria for EPA 25(b) Exemption or • OMRI approved product or • Human acute toxicity is low • No evidence of carcinogenicity • No evidence of neurotoxicity • No evidence of endocrine disruption • No evidence of reproductive toxicity • No evidence of mutagenicity or other serious human health concerns • Poses minimal harm to wildlife, soil health, ecosystem function or biodiversity • Minimal concern as water pollutant • Persistence less than 30 days • Low to extremely low soil mobility • Exceeds all criteria for conditional or restricted categories	• Low in acute toxicity and chronic health hazards • Low or moderate toxicity to non-target organisms, including soil health and other ecosystem impacts • Application method avoids or limits non-target organism exposure and/or risk • Not listed as PBT (persistent, bioaccumulative or toxic chemical) • Persistence less than 100 days or is mitigated by targeted application that minimizes exposure to soil and/or water • Low or moderate soil mobility	• EPA restricted use pesticide or • Mammalian LD50 of 50 mg/kg or • Systemic insecticide and/or • Has one or more of the following factors: ○ Known, likely or probable carcinogen ○ Known or suspected reproductive toxin ○ Probable or known endocrine disruptor ○ Known or suspected mutagen ○ Known or suspected neurotoxin ○ Known or suspected to cause organ damage ○ Known or suspected chromosomal or genetic damage ○ Water pollutant ○ Extremely/highly toxic to birds ○ Extremely/highly toxic to aquatic organisms ○ Extremely/highly toxic to bees ○ Extremely/highly toxic to wildlife ○ Persistence is greater than 100 days ○ High or very high soil mobility ○ Not listed as PBT (persistent, bioaccumulative or toxic chemical)	• Product not registered with state of Colorado** • Organophosphate chemicals • Carbamate chemicals • Neonicotinoid insecticides • Glyphosate herbicides • Contains inert ingredient of EPA toxicological concern (List 1 or 2) • Has one or more issues identified in the Special Use category without adequate or acceptable mitigation to address human health and/or environmental concerns. • Disrupts ecosystem function or potentially impacts biodiversity objectives for the site • Contributes significantly to build-up of greenhouse gases, climate change, or destruction of the ozone layer • Significant risk to threatened or endangered species

*Pesticides from all tiers may only be used as a last resort.
** Does not apply to EPA 25(b) exempt products.

Pesticide Assessment Process

Request Product

A staff member can request that a pesticide be assessed for addition to the approved pesticide. The request should be sent to the citywide IPM coordinator and include:

1. Name of product – active ingredient and brand name/formulation
2. Product label
3. Justification for proposed use
   a. Target pest
   b. How, where and when it would be used
   c. Other options, such as non-chemical methods or other pesticides that are currently on the approved pesticide list
   d. Timing – when the is product needed. Is it an urgent issue? Does the staff member need help to identify other options?

Screen Product

Rapid Screening: A rapid screening is first conducted using regulatory data before a full assessment is conducted. If a pesticide falls under the Failed Hazard Tier, it cannot be used. A pesticide that is categorized as "Restricted Use" is unlikely to be approved unless there are no other options available and the risk of the pest to human health or ecosystem services exceeds the risk of a pesticide in this category. This typically requires a formal management plan and the approval of the IPM Coordinator and the department director. If enough justification is given to consider a pesticide in the "Restricted Use" category, a complete assessment will be completed to mitigate its impacts as much as possible. Please note that a pesticide that initially screens as "Conditional," may be reclassified as "Restricted Use" if the full assessment uncovers additional information that fits those criteria.

Full Assessment: A qualified staff member (usually the IPM coordinator) or a consultant will assess the product and assign it a hazard tier using the following process:

1) Obtain products label(s) and SDS sheet(s) and review.
2) Check Colorado Department of Agriculture database to determine if the product is registered in Colorado
3) Search regulatory databases for risk assessment information
   a. Environmental Protection Agency (EPA)
   b. Pesticide Properties Database (PPDB)
   c. Conduct a general search to find other regulatory information from other countries and California

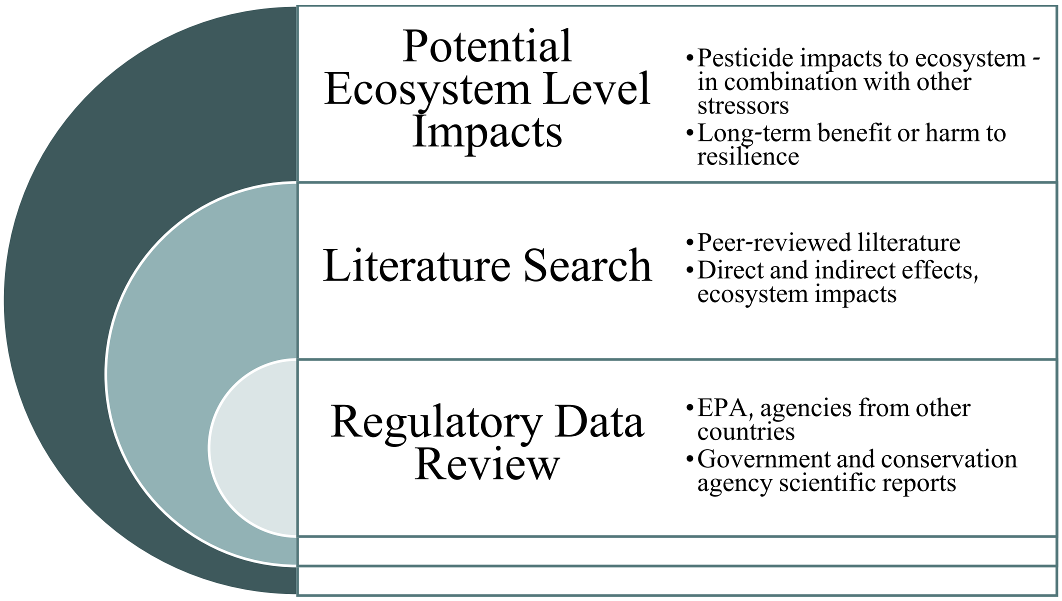
4) Check to see if other assessments have been conducted by other entities, including, but not limited to:
    a. The U.S. Forest Service
    b. Thurston County, Washington pesticide assessments
    c. San Francisco
5) Search the independent literature for any relevant research/studies
    a. A significant portion of these papers are behind paywalls, requiring access to a university library database. Alternatively, an email request can be sent to the corresponding author of the paper to obtain a copy.
    b. Review each paper for pertinent information, particularly non-target or ecosystem impacts that could create new issues or undermine city objectives or site-specific management objectives.
6) After careful review of all documents, the information is entered into a spreadsheet to indicate different levels of toxicity from regulatory data and the literature search.
7) The data in the spreadsheet is assessed against the city's Hazard Tier Criteria
8) If a pesticide fails, it will not be included in the approved pesticide list
9) If a product meets the criteria for the Allowed or Conditional Tier, it will be included in the approved pesticide list and any restrictions will be noted.

Ecological Risk Management

In addition to the weaknesses of the pesticide regulatory system for individual species, briefly addressed above, the EPA does not assess ecological risk at the population and community levels and does not take into account indirect and multi-trophic effects. The lack of appropriate ecological risk assessment contributes to widespread chemical contamination that has resulted in significant biodiversity decline. Ecosystems are exposed to mixtures of pesticide active ingredients, adjuvants, breakdown products, pharmaceutical compounds, other synthetic chemicals and nutrient pollution, in addition to other anthropogenic ecosystem stressors from increased heat, drought, flooding, light pollution, etc. Each stressor can potentially impact individuals and communities, but multiple stressors may have more than additive effects that adversely affect individuals as well as the resiliency of ecosystems.

Research groups are developing approaches to understand and assess the ecological risk of pesticides to whole ecosystems within the context of multiple stressors and how this impacts the resilience of ecosystems. Many of the stressors, such as climate change, are outside our immediate control. The application of toxic chemicals is a stressor that we can reduce or eliminate, particularly when information about a particular substance indicates toxicity to individual organisms with likely cascading impacts through indirect effects.

The city's process uses whatever information is available about a pesticide and applies ecological principles along with knowledge of the site that's being managed and the surrounding areas.



Assessing Pesticide Use for Arthropod-Borne Disease

A vector-borne disease is when a blood-feeding organism like tick or insect (i.e., mosquito or flea) becomes infected with a pathogen from one animal and then transmits it to another host animal, including mammals and people, birds and reptiles. Vector-borne diseases are/have been major global health issues for humans including malaria, Lyme disease, West Nile virus, and bubonic plague. Wildlife is also susceptible to major population declines from vector-borne diseases. These disease cycles add layers of complexity to understanding their ecology and the conditions that favor the pathogen and how it moves through the vector and different hosts.

There is a relationship between biodiversity and infectious disease. Higher biodiversity tends to correlate with lower incidence of disease, likely due to competition between vectors, differing capacities of host species to become infected, and the abundance of predators and natural enemies to control vector populations. The health of host animals can improve in high biodiversity areas with stable ecosystems that provide adequate food sources.

These complex dynamics are altered by environmental stressors and declines in biodiversity are associated with higher disease incidence, while both diverse parasite and diverse host species have been shown to lower disease transmission. The common approach to vector management is reliant on pesticides to directly control the arthropod pest. To reduce the environmental and human health risks from pesticide use, an ecosystem management approach is needed, particularly with added impacts from climate change, to maintain biodiversity and reduce disease risk. An example of using an ecosystems management approach to reduce the risk of a vector-borne disease, West Nile virus, is the city's mosquito management program.