

**Best Practices for Implementation of
Invasive Plant Control for Resource Management
on the
Nature Reserve of Orange County**

**Under the Orange County Central and Coastal Subregion Natural
Community Conservation Plan/Habitat Conservation Plan and Permit**



April, 2018

Board of Directors approved March 15, 2018

Supported by the **U.S. Fish and Wildlife Service**, and the **California
Department of Fish and Wildlife**, April 17, 2018

Supported by the **California Invasive Plant Council**, June 7, 2018

(Letters attached)



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In Reply Refer To:
FWS/CDFW-OR-18B0167-18CPA0187

April 17, 2018
Sent by Email

Mr. Jim Sulentic
Executive Director
Natural Communities Coalition
13042 Old Myford Road
Irvine, California 92602

Subject: Support for Best Practices for Invasive Plant Control in the Nature Reserve of
Orange County, Orange County, California

Dear Mr. Sulentic:

This letter is in response to your request, on behalf of the Natural Communities Coalition (NCC), to review and approve the “Best Practices for Implementation of Invasive Plant Control for Resource Management on the Nature Reserve of Orange County” and the associated “Invasive Plant Management Protocols and Procedures.” These documents were approved by the NCC Board of Directors on March 15, 2018.


Recent restrictions on the use of synthetic herbicides within local jurisdictions of Orange County prompted NCC, in collaboration with its partners, to develop a strategy that is consistent with local policies while enabling signatory jurisdictions and participating landowners to meet their management obligations under the County of Orange Central and Coastal Subregion Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP).

The U. S. Fish and Wildlife Service (Service) and California Department of Fish and Wildlife (Department), collectively referred to as the “Wildlife Agencies,” issued permits to participating jurisdictions and participating landowners for implementation of the NCCP/HCP, which addresses development, conservation, and land management activities throughout much of central and coastal Orange County. The permits authorize impacts to covered species from development and land management activities in exchange for commitments by permittees to conserve and manage covered species’ habitat in the NCCP/HCP reserve system (also referred to as the Nature Reserve of Orange County). One of the primary commitments made by permittees is to maintain the long-term habitat value of the reserve system and its ability to support viable populations of covered species (Section 4.4 NCCP/HCP Implementation Agreement; Section 5.2 NCCP/HCP). Control of non-native invasive plant species is essential to maintain the long-term habitat value of the reserve system.

The Wildlife Agencies previously reviewed the above referenced documents and submitted comments and recommendations that have been incorporated into the final Board approved versions. We conclude that, although the proposed approach is conservative with respect to potential use of synthetic herbicides, it incorporates sufficient flexibility to meet the permittees' commitments under the NCCP/HCP, and we support the use of these documents by land owners within the plan area to guide the control of non-native species. We recommend that future annual reports by participating landowners implementing the proposed strategy explicitly address the effectiveness of the strategy and include recommendations for improvements to the strategy, if necessary. We appreciate NCC's ongoing coordination and partnership and their work to successfully implement the NCCP/HCP. If you have any questions, please contact Jonathan Snyder of the Service at (760) 431-9440, extension 307, or David Mayer of the Department at (858) 467-4234.

Sincerely,

Karen A. Goebel
Assistant Field Supervisor
U.S. Fish and Wildlife Service



Gail K. Sevens
Environmental Program Manager
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June 7, 2018

Mr. Jim Sulentic, Executive Director
Natural Communities Coalition
13042 Old Myford Rd.
Irvine, CA 92602

Dear Mr. Sulentic,

I am writing on behalf of Cal-IPC to support NCC's recently adopted documents on invasive plant control using IPM (integrated pest management). These documents—"Best Practices for Implementation of Invasive Plant Control for Resource Management on the Nature Reserve of Orange County" and "Invasive Plant Management Protocols and Procedures"—outline an effective and safe IPM approach for controlling invasive plants, including the judicious use of herbicides.

Controlling invasive plants is an essential part of meeting the conservation goals set out for the Reserve. Thank you for NCC's leadership in environmental stewardship.

Sincerely,

Doug Johnson
Executive Director

Summary

The Central Coastal Orange County Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP) is a regional conservation and development permit issued in 1996 by federal and state regulatory agencies that has allowed development to proceed on certain habitat lands in Central and Coastal Orange County in exchange for protection and permanent management of native habitats and rare species on other protected lands. Totalling nearly 38,000 acres, these protected lands are collectively known as the Nature Reserve of Orange County (NROC or Reserve).

The permittees and signatories to the NCCP (Appendix A) are committed to protection and long-term management of their lands in the Reserve to the standards of care established in the NCCP/HCP Plan and Implementation Agreement. These include adaptive management of the Reserve to maintain no net loss of habitat value over time, and active management to ensure the long-term health and viability of the Reserve (NCCP, Chapters 4 and 5; hereafter 'Standards of Care'). Further, the NCCP states that this specific commitment to continued viability and even improvement of habitat conditions over time by the permittees is what enabled regulatory approval and permitting of habitat loss and take of protected species elsewhere through the process of development. These standards of care in management are directly related to compliance with the NCCP/HCP and are not discretionary on the part of signatory parties.

Natural Communities Coalition (NCC) is the 501(c)(3) not-for-profit corporation established by the NCCP/HCP to coordinate the activities of permittees and participating managers. Among other responsibilities, NCC oversees compilation of annual reports on Reserve management and coordinates implementation of the NCCP/HCP on issues that transcend individual jurisdictions, such as fire management, recreation, and habitat restoration and enhancement, and invasive species control. The board of directors of NCC is comprised of the landowning signatories to the NCCP/HCP Permit as well as the United States Fish and Wildlife Service and the California Department of Fish and Wildlife (collectively referred to as the Regulatory Agencies or Wildlife Agencies), several public members and *ex officio* representation from interested public agencies and nonprofit organizations (see Appendix A).

Individual signatories implement the NCCP/HCP Standards of Care on their lands through Resource and Recreation Management Plans (RRMPs) which are reviewed by the regulatory agencies for consistency with the Permit. These plans describe the authorized activities and management of the land including trails and visitor infrastructure, natural resource management and habitat restoration, and the terms and conditions of public access and use. Along with annual reporting requirements, the RRMPs ensure that the Reserve is consistently

managed over time among all the landowners to remain compliant with the Standards of Care and terms of the NCCP/HCP permit.

Two fundamental components of NCCP/HCP implementation on the Reserve are Invasive Species Control Programs and Habitat Restoration Programs. Individual landowners and permittees are responsible for implementing their own management programs on their lands enrolled in the Reserve. The fundamental objectives of the two programs are: (1) to protect and enhance the preserved natural habitats and their underlying biological diversity to achieve no net loss of habitat value, and (2) to ensure compliance with the NCCP/HCP permit and resource management obligations and standards of care on the Reserve. To achieve these Standards of Care for the NCCP/HCP, NCC has supported a number of activities of individual permittees through supplemental funding, research, mapping, contract management, and other essential functions.

Compliance with Federal and State Laws and Policies

Outlined here are Best Practices to ensure the Standards of Care are met by permittees for the management of invasive species. These Best Practices are derived in part from those developed and in use by the United States Department of Interior and are provided to land owners and managers of the Reserve as a way of balancing the ecological health of the systems and species for which the NCCP/HCP Reserve was established while meeting human, financial and fiduciary priorities. The relevant federal regulations are described in the United States Department of the Interior Departmental Manual on Environmental Quality Programs focused on Invasive Species Management¹ and Pesticide Use² and conform to the Federal laws and other authorities listed in Appendix B.

The State of California regulates pesticide through the Department of Pesticide Regulation of the CA Environmental Protection Agency. The laws, regulations, policies and guidelines for use of pesticides in the state are described in the Guide to Pesticide Regulation 2017.³

The federal and state Best Practices emphasize using an integrated pest management (IPM) approach to invasive species control. As defined by the California Department of Pesticide Regulation, IPM is a science-based, decision-making process that combines biological, physical and chemical tools in a way that achieves control objectives while minimizing economic, health and environmental risk. Through the adoption of the IPM approach, the Natural Communities Coalition commits to the following overarching goals:

¹ US Department of the Interior Department Manual (2017). Series: Environmental Quality Programs, Part 524: Invasive Species Management, Chapter 1: Invasive Species Policy

² US Department of the Interior Department Manual (2017). Series: Environmental Quality Programs, Part: 517: Pesticides, Chapter 1: Integrated Pest Management Policy

³CA Department of Pesticide Regulation (2017), A Guide to Pesticide Regulation in California: 148pp.

- Conduct all pest management activities in full compliance with applicable laws and other authorities required at the federal and state levels (see Appendix B for a listing of the major applicable federal laws and authorities). Participating land owners and managers, and/or their appointed representatives will complete required environmental documentation before conducting pest management activities and reporting afterward.
- Give full consideration to the safety and protection of humans and other non-target organisms and resources while achieving control objectives.
- Establish site management objectives and then choose the approach that represents the lowest risk, while most effective for each pest management project. The methods can include, but are not limited to, one or more of the following: no action, cultural, physical, biological, and chemical management. Land owner and manager planning will incorporate IPM methods into short- and long-term planning documents to establish methods for implementing low-risk, effective pest management practices. While management costs are important, they are not the primary deciding factor in selecting a management approach. At times, it may be appropriate to select a more expensive management approach if that method is effective and reduces risks to humans and other non-target resources.
- Conserve and promote beneficial organisms and natural processes that inherently suppress potential pest populations.
- Design and maintain the stability of structures, developed landscapes, trails and visitor infrastructure, and natural areas to prevent and reduce conditions conducive to pests.
- Utilize and promote pest management research, methods, education, and technical assistance programs to develop, support, and implement IPM strategies.
- Conduct appropriate and applicable pest detection, environmental surveillance, and monitoring before, during, and after management activities to determine whether pest management goals are being achieved and whether the activity caused any significant unanticipated effects.
- Incorporate this policy into procurement activities, contracts, leases, and agreements to ensure compliance by land owners and managers, and outside parties conducting activities on or adjacent to Reserve properties such as homeowner associations, construction contractors, operation and maintenance of irrigation systems, concessions management, roads, rights-of-way, public health, and animal and vegetation management.

Below is a summary of the goals and standards of the Invasive Plant Control and Habitat Restoration Programs and Best Practices for their implementation.

Invasive Plant Control Coordination on the Nature Reserve of Orange County

Participating landowners in the NROC coordinate their activities under the Coastal Invasive Plant Management Program that targets specific non-native plant species that have a high potential to reduce reserve health, viability and loss of regional habitat values over time by crowding out native plants, increasing fire risk, usurping water resources, and reducing native species diversity. High priority invasive plant species are removed both through regular annual field work programs by land owners and managers, and through an Early Detection and Rapid Response (EDRR) program coordinated by NCC to identify and eliminate new or emerging invading species likely to spread quickly and cause costly environmental damage (e.g., Sahara mustard). The list of priority invasive plant species addressed by this Program is shared across multiple land owners, including Orange County Parks, California State Parks, Irvine Ranch Water District, the City of Irvine and the City of Newport Beach for the entire 38,000-acre Nature Reserve of Orange County.

The NROC Invasive Plant Management Program priorities are to eliminate non-native species with high potential to spread further and degrade protected habitats and to ensure no further spread or habitat degradation by those that are currently established. Success entirely depends on consistent, thorough reduction of invasive plant populations over time. Given the highly competitive and prolific nature of invasive plants, if even a small percentage of plants survive and reproduce successfully, treatments may require significant additional effort and financial investment, and set eradication trajectories back for years or permanently (Figure 1). This is fundamentally important for implementation of the NROC Invasive Plant Management Program and efforts to implement IPM principles, because tools and techniques to control invasive plants must achieve a very high level of effectiveness to be successful. For example, 80% effectiveness in control (which may be acceptable in non-habitat areas) is unacceptable for the vast majority of invasive plant species that are currently expanding in the NROC, because allowing 20% of an invasive species population to survive and reproduce annually does nothing more than change the long-term population trajectory of the invasive plant. It continues to expand, albeit at a potentially slower rate. This slows habitat degradation but still results in net habitat loss over time which is inconsistent with the obligations under the Standards of Care set by the NCCP/HCP permit.

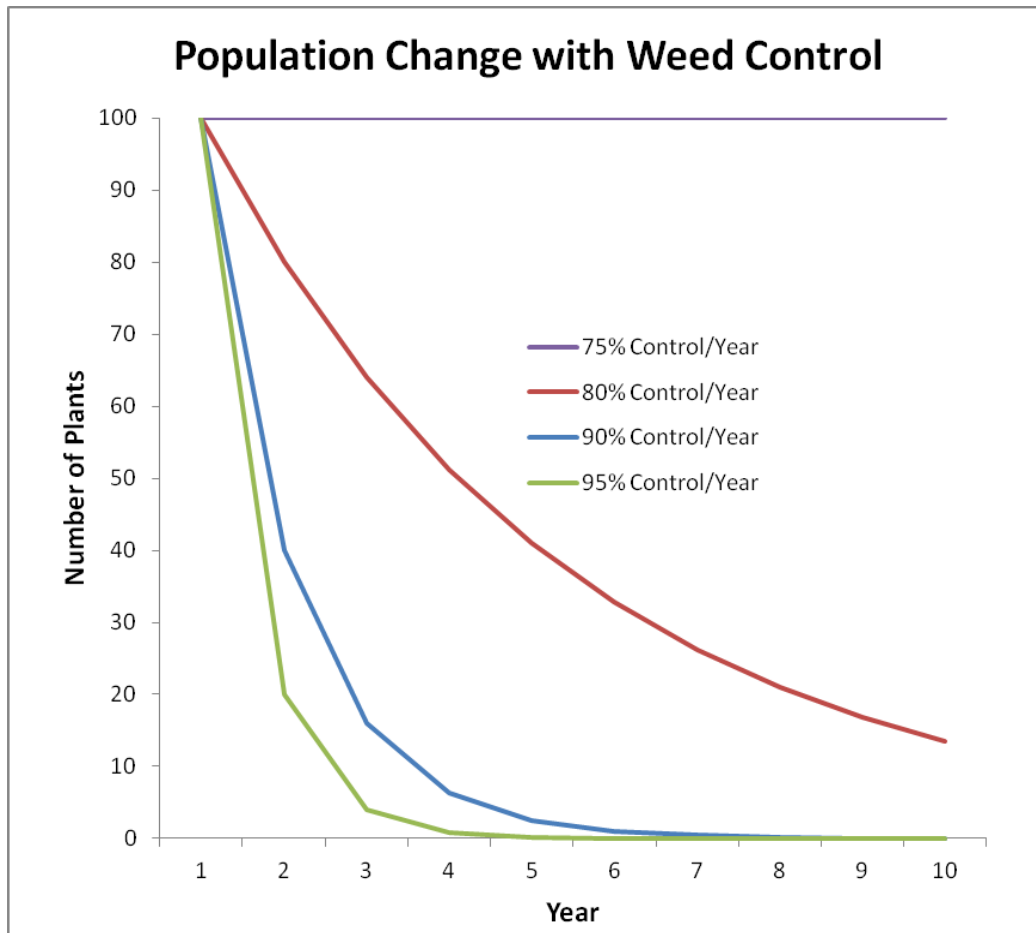


Figure 1. Predicted population change over time for a model invasive plant under constant 75%, 80%, 90% and 95% control efficacy. The modeled population has an average reproductive output of 20 viable seeds per plant, 20% survival from seed to maturity, and no seed dormancy. **Many target invasive plant species far exceed these reproductive outputs, which means this graph represents the best possible scenario.** When invasive species maintain seed dormancy (such as black mustard or Russian thistle), this trait may significantly prolong the time to effective control.

For further information about modeling invasive species population growth and control, see: 1) Moody, M.E. and R.N. Mack. 1988. Controlling the spread of plant invasions: the importance of nascent foci. *J Applied Ecology* 25: 1009-1021. and 2) Buyuktahtakin, I.E., Z. Feng, G. Frisvold, F. Szidarovsky and A Olsson. 2011. A dynamic model of controlling invasive species. *Computers and Mathematics with Applications* 62: 3326-3333.

Habitat Restoration

The objective of the Habitat Restoration Program under the NCCP/HCP is to convert non-native annual grasslands or habitat areas degraded by non-native species (often former livestock grazing areas) to native perennial habitats of coastal sage scrub and native bunch grass that functionally support a greater diversity of wildlife and native plants. Active restoration consists of aggressive invasive plant control to levels which allow for successful establishment of seeded and/or planted native plants, and long-term maintenance of these plants until restored areas

achieve similar function and resilience to that of similar desired plant communities considered healthy in the region (see Suding *et al.*, 2008). Some NCCP/HCP signatories, such as the City of Irvine, have a further existing legal obligation to completely restore certain acreages of native habitat in exchange for loss of habitat areas in the NROC that were developed for staging area and trail construction under their RRMPs to provide expanded public access.

Typically, native habitats are restored using locally grown or collected native seed, or transplantation of native plants in containers. In general, seeding with diverse native seed mixes is highly preferable to using transplants because it increases native plant community diversity relative to transplanting, minimizes soil disturbance, reduces risk of soil pathogen introduction, reduces the need for irrigation, and lowers overall restoration costs. Site preparation for successful restoration requires near complete elimination of invasive species so that native seedlings can become established without competition. Many invasive plant species can easily outcompete natives during the establishment phase, while natives can gain a competitive advantage once they are established. Invasive control in preparing a site for restoration requires elimination of all undesirable non-natives above ground and control of the annual grass seedbank, rather than a few target species or individuals. Incomplete removal increases the competitive advantage of non-natives and reduces the likelihood of restoration success. Habitat restorations are in progress throughout the NROC.

Best Practices for Invasive Species Management for Achieving NCCP/HCP Standards of Care

NCC has coordinated the Invasive Plant Control and Habitat Restoration programs in the NROC for over 20 years, consistent with the terms and conditions of the NCCP/HCP and established IPM principles. This includes prioritizing manual control and non-synthetic chemicals where effective and cost-efficient, supplemented by synthetic herbicide where necessary to achieve the control mandates described herein. Mention of any product brand name does not represent an endorsement of that brand, but an example of a potential suitable product to achieve control with a certain compound.

The perception exists among some members of the public that non-synthetic herbicides pose lower risk to people and to native habitats relative to synthetic herbicides. While this perception is not currently supported by scientific research consensus, some landowners have chosen to restrict the use of synthetic herbicides on wildlands. Some (e.g. Marin Municipal Water District) have eliminated their use entirely. As a result of these considerations, managers may choose to employ non-synthetic herbicides as a first priority, and apply synthetic herbicide when other alternatives do not achieve required or desired outcomes. In circumstances where synthetic herbicides are used, they have been shown to successfully control priority invasive species at application doses that are a fraction of those permitted on the label. For example, in 2015, Irvine Ranch Conservancy working for the City of Irvine applied approximately 64 ounces

(before dilution) of the synthetic herbicide glyphosate on the City's Open Space Preserve lands in the NROC. In addition, managers should use methods that minimize the potential for exposure to the public and applicators, such as spot spraying and stump cut application.

The following Best Practices described below are based on the results of documented field trials and long-term experience and results of managers on both the NROC and in other wildland areas. The protocols identified here are expected to achieve the NCCP/HCP invasive species control objectives while minimizing or eliminating potential for public exposure to any of the compounds used, whether non-synthetic or synthetic.

Consistent with generally accepted IPM principles, managers should prioritize manual control of species where effective and cost efficient, as well as in areas with higher potential for public exposure (i.e., trailsides). Non-synthetic herbicide may be used wherever possible to safely achieve control requirements when manual control will be ineffective or impractical, such as remote areas or off-trail. Most non-synthetic herbicides control invasive plant species by damaging exposed plant tissues on contact. There are a number of non-synthetic herbicides available that operate by the same method of action. Based on label specifications, chemical composition, and local experience as well as field trials from other researchers and land managers, non-systemic herbicides with contact-kill action are most effective at controlling young, small seedlings with decreasing efficacy as plants age and grow.

Contact-kill non-systemic herbicides are somewhat effective at controlling certain annual forb species and should remain the preferred alternative when it accomplishes needed control results. Based on results from field trials in the NROC, managers should use contact-kill non-synthetic herbicides early in the growing season to control annuals (e.g., tocolote, filaree and mustards), particularly for the purposes of site preparation and maintenance of new habitat restoration areas. However, their efficacy is expected to significantly diminish as the growing season progresses and contact-kill non-systemic herbicides are generally ineffective past late winter. Non-systemic herbicides are least effective on established invasive plant populations.

To control species or populations not eliminated by non-systemic herbicides, managers should utilize synthetic "Caution" label herbicides consistent with generally accepted IPM principles in the lowest possible dose necessary to achieve control objectives. The brands found most effective for the priority target invasive plant species in the NROC and for site preparation in habitat restoration are Fusilade® (fluazifop, a grass-specific herbicide), Element 4® (Triclopyr, a broad-leaf specific herbicide), and Transline® (clopyralid, another broad-leaf herbicide especially effective on asters). These chemicals are not listed under the California Safe Drinking Water and Toxic Enforcement Act of 1986 (Prop. 65). A fourth herbicide, Roundup® (glyphosate) should be used where effective control cannot be achieved by the first three, and should be applied in the lowest dose necessary to accomplish control.

All herbicides, whether synthetic or non-synthetic, should be applied by a California Department of Pesticide Regulation licensed business or an organization with a certified or licensed applicator to supervise the application. All use of herbicides on lands enrolled in the NROC should be reported in management reports as required in the NCCP/HCP as well as, if EPA registered, in required reports to county and state pesticide regulatory authorities, including amounts, concentrations and application methods. Managers should also obtain herbicide use recommendations from state-licensed Pest Control Advisors.

Since manual removal may be more effective than non-systematic products in certain situations and with specific species, managers should use manual control for perennial species as they have the capacity to do so within funding and labor constraints. Manual removal is the most expensive and labor intensive method of invasive species control and therefore its overall role in the NROC Invasive Plant Management Program is likely to be limited by available funding and labor. Nevertheless, manual cutting is an important component of overall integrated invasive species management for the NROC.

Managers are encouraged where feasible to conduct empirical field trials with invasive species control products as they become available. If conducted, these trials should be implemented concurrently with regular ongoing invasive species control activities to ensure that target species control objectives are not compromised during field trial periods. Special attention should be paid to effects of tested herbicides on surviving native and non-native vegetation in field trials. For example, two currently-available non-synthetic non-systemic products (Avenger® and FinalSanPro®) offer the potential to contribute to overall invasive species control, particularly for habitat restoration and in areas with non-native annual grasses. It should be noted that FinalSan® contains nitrogenous compounds that have been demonstrated to act as fertilizer in the soil. While this may be a desirable outcome for lawns and other non-habitat green spaces, native plants thrive in a nitrogen-poor rather than nitrogen-rich environment, while invasive annual species prefer higher nitrogen levels. The net effect of these chemicals on native species is likely to be negative and to promote non-native invasive species growth in a wildland setting.

Invasive Plant Species Control Protocols

This section establishes the protocols and methodologies that should be employed on the NROC to achieve the habitat management and restoration mandates in the NCCP/HCP and the established Standard of Care for the land (i.e., no net loss of habitat value) with priority given to minimizing or eliminating exposure to the public and applicators. As identified here, effective control is considered to be greater than 80% kill of target invasive species.

To accomplish this objective, Weed Control Protocols should follow generally established Integrated Pest Management principles, including:

- Prevent transfer and establishment of invasive plant species by practices such as cleaning field equipment and vehicles and using invasive seed-free materials (e.g. gravel, soil, straw wattles, etc.)
- Use of manual, mechanical, or cultural control methods where practical, cost-effective, and able to achieve control mandates.
- Where manual, mechanical, or cultural control methods are impractical, not cost-effective, or do not achieve control mandates, preference should be given to EPA Level III “Caution” label herbicides that achieve effective (80% or better for most species) control. As a result of cultural or other considerations, managers may prioritize non-synthetic herbicides that achieve control mandates.
- Where EPA Level III “Caution”-label non-synthetic herbicides are used and do not achieve control mandates or are not practical or cost-effective, EPA Level III “Caution” label synthetic herbicides may be used, with preference given to herbicides not listed on CA Prop 65.
- EPA Level II “Warning”-label and/or Prop 65-listed herbicides (synthetic and non-synthetic) may be used if the other methods above do not adequately achieve control objectives and use of these herbicides can achieve the desired level of control over that of herbicides used above.
- EPA Level I “Danger”-label herbicides may only be used in circumstances where all other methods of control are ineffective and habitat health is critically at risk and use of these herbicides can achieve the desired level of control.
- In all cases, the use of herbicides should not be a substitute for maintaining the practices described in the first two bullets above.

When determining which herbicides to use under the above protocols, managers should also consider the risk vs. benefit of EPA label warnings in the context of wildland applications. Many herbicides labeled as EPA Level 1 “Danger” are in that category because of human eye risk to the applicator, not because they are systemic toxicants or a danger to habitats or wildlife. Triclopyr (Garlon®) for example, comes in two forms, Garlon 3A®, that is labeled Level 1 “Danger” because of applicator eye risk, and Garlon 4®, which is labeled Level 3 “Caution”, but has a significantly greater ecological risk to aquatic organisms than the Level 1 “Danger” form of the chemical.

Managers should only apply herbicides with the supervision of a licensed applicator and in consultation with a certified Pest Control Advisor. All required reports of herbicide use must be submitted to the appropriate oversight agencies as well as in annual reports under the NCCP/HCP.

Management Activities

There are four basic types of management activities that involve invasive plant control in the NROC: trail maintenance, habitat restoration, control of identified target invasive plant species, and infrastructure maintenance activities covered by the permit. Infrastructure maintenance is not specifically described below as it generally falls in developed areas and may be covered by other protocols. However, the invasive species control mandates in the NCCP apply equally to infrastructure maintenance, and these areas may be especially significant vectors of non-native species into wildlands.

The protocols for each activity in the Open Space Preserve will include:

Routine Trail Maintenance

Trails are the primary means of public access to the NROC. In general, there are two kinds of trails maintained by participating landowners and managers – those open to daily self-guided access and those with managed access through regular docent led tours and monthly self-guided Wilderness Access Days. With minimal exception, landowner policies mandate that visitors remain on trails at all times, therefore the realistic potential for public exposure to any herbicides used off-trail is negligible. Trailheads and staging areas provide higher potential for public exposure, which should be considered when invasive species control is conducted. In many cases, trails are a primary vector for invasion of non-native plant species into healthy habitat, habitat restoration sites, or other areas of the NROC, (e.g. Russian thistle, black mustard) and therefore trailside areas are important for invasive species management and eradication.

Habitat Restoration

Habitat restoration is a management priority of the NCCP/HCP, NCC, and the signatories to the permit. For some parties, such as the City of Irvine, it also fulfills obligations under approved Resource and Recreation Management Plans (RRMPs) to provide restoration acres to offset previous trail and trailhead construction. Habitat restoration generally takes place away from trails but may be trailside as well.

Targeted Invasive Species Control

Control and/or elimination of specific highly-invasive species is a very high priority management action under the NCCP/HCP and the Invasive Species Management Program. Maintenance of no net loss of habitat value, including by maintaining the health and long term condition of habitats, is a compliance obligation under the NCCP/HCP. Controlling certain invasive plant species also reduces fire danger in high-risk areas such as the Wildland Urban Interface (adjacent habitat and developed edges). Wildfire risk in the NROC along with associated risk to human communities is significant because the NROC has a very large amount of Wildland Urban Interface. Also, due to the high priority placed on the control of target invasive plant species under the NCCP, NCC has previously contributed supplemental annual funding to individual signatory landowners and is likely to do so in the future. The list of Target Invasive Plant Species is found in Appendix C. Table 1 below describes recommended protocols for control of various target species in the NROC.

Table 1. Summary of experience and recommended non-native invasive species control methods for key invasive species in the Nature Reserve of Orange County (NROC) under the Central Coastal Orange County NCCP/HCP.

(Note: A methodology is considered effective if it results in greater than 80% kill)

Species	Effective Non-synthetic Methodologies (>80% removal)	Ineffective Methodologies (<80% removal)	Recommended Method	Reference
Artichoke Thistle	-2 years of manual basal-cut, 4-8 visits per year -2 years or root-cut, 2 visits per year	- Single basal cut -Suppress® at 9% (presumed)%	-In remote areas off trail: Single dose synthetic herbicide at PCA recommended application rate; Low dose Roundup® if synthetic herbicide is not effective. -Near daily accessible trails and staging areas: Manual basal- or root-cut method, -Follow-up with manual cut to eliminate seed set	Irvine Ranch Conservancy, unpublished research; DeSimone (2011); DiTomaso, Kyser et al. (2013)
Bull Thistle	-Manual whole-plant removal	-Single cut	-Manual removal pre-flower	DiTomaso, Kyser et al. (2013)
Castor Bean	-Small Plants: Manual whole-plant removal	-Single cut - Manual removal of mature plants	-Small Plants/Seedlings: Manual control by hand pulling -Large/Adult plants: Single dose Element® at PCA-recommended rate in uplands; Low dose Roundup® if	DiTomaso, Kyser et al. (2013)

Species	Effective Non-synthetic Methodologies (>80% removal)	Ineffective Methodologies (<80% removal)	Recommended Method	Reference
Castor Bean (cont)	-Large trees (>2" diameter): no effective method	- Non-synthetic herbicide	Element is ineffective -Follow-up with manual removal of seedlings/small plants	
Fennel	-Small Plants: Whole plant removal -Established Plants: none	-Single cut -Suppress® at 5-6%	-Single dose Triclopyr® in uplands; low dose Roundup® if Triclopyr is ineffective -Follow-up with manual cut and manual removal of seedlings where needed	Irvine Ranch Conservancy, unpublished research; DiTomaso, Kyser et al. (2013)
Garland Chrysanthemum	-Small Plants: Whole plant removal -Established Plants: no effective method	-Single cut -Suppress® at 9%	-Small stands (less than 100 plants): Manual control by hand pulling -Large stands: Single dose Transline® at PCA-recommended rate; low dose Roundup® if Triclopyr® is ineffective -Follow-up with manual removal of seedlings/small plants	Irvine Ranch Conservancy, unpublished research
Linear-leaved Australian Fireweed	-Small Plants: Whole plant removal	-Single cut	-Single dose Transline at at PCA-recommended rate in uplands; low dose Roundup® if Transline® is ineffective	Irvine Ranch Conservancy, unpublished research

Species	Effective Non-synthetic Methodologies (>80% removal)	Ineffective Methodologies (<80% removal)	Recommended Method	Reference
	-Established Plants: no effective method		-Follow-up with manual removal of seedlings/small plants	
Perennial Pepperweed	None	Single cut Single pull Multiple pull	Monitoring and manual removal of re-sprouts. Single dose Telar® only if additional mature plants are found	Note: Currently perennial pepperweed is only found on the NROC on a limited basis and potentially can be contained. Telar® (Chlorsulfuron) is the most effective chemical.
Poison Hemlock	-Small Plants: Manual whole plant removal -Established Plants: none	-Single cut - Non-synthetic herbicides	-Small Plants/Seedlings: Manual control by hand pulling -Large Plants/Adults: Single dose Element® at PCA approved rate for upland; low dose Roundup® if Element® is ineffective -Follow-up with manual cut and manual removal of seedlings where needed	DiTomaso, Kyser et al. (2013)
Sahara Mustard	-Seedlings: Suppress® (assume similar behavior to black	-Single cut -Single pull	-Small stands: Manual control by hand pulling (and bag if in seed) -Large stands (early season): Single dose Suppress® -Follow-up with	Irvine Ranch Conservancy, unpublished research; DiTomaso, Kyser et al. (2013) (Efficacy of Suppress® still to be tested)

Species	Effective Non-synthetic Methodologies (>80% removal)	Ineffective Methodologies (<80% removal)	Recommended Method	Reference
	mustard) -Larger plants: Whole plant removal		multiple (3-4) manual pulls	
Spanish Broom	-Small plants: manual removal -Large plants: no effective method	-Single cut -Multi-cut -Non-synthetic herbicide on mature plants	-Single dose Element® cut stump at PCA-recommended rate --Follow-up with manual removal of seedlings where needed	Irvine Ranch Conservancy, unpublished research; DiTomaso, Kyser et al. (2013)
Stinknet	Isolated plants: manual removal	Currently unknown	-Manual control by hand pulling adjacent to trail. - Monitoring for additional populations	Irvine Ranch Conservancy, unpublished observations; further recommendations pending from San Diego working group.
Tamarisk	-Small plants: manual removal -Large plants: no effective method	-Single cut -Multi-cut	Single dose Element® cut stump at PCA-recommended rate; Roundup® if Element® is ineffective --Follow-up with manual removal of seedlings where needed	Irvine Ranch Conservancy, unpublished research; DiTomaso, Kyser et al. (2013)
General Habitat	- Invasive plant	-Suppress at 5-	-Mowing and manual control	Irvine Ranch Conservancy, unpublished

Species	Effective Non-synthetic Methodologies (>80% removal)	Ineffective Methodologies (<80% removal)	Recommended Method	Reference
Restoration Site Prep and Maintenance	<p>Seedlings: Suppress® on annual forbs</p> <p>-Broad-leafed invasive species: Manual removal or mowing</p> <p>- Annual Grasses: no effective method</p>	6% on annual grasses and Russian thistle	<p>- Single application of low-dose synthetic herbicide to achieve control objectives</p> <p>-Concurrent field trials with Suppress® and other non-synthetic herbicides</p>	research
Trail Maintenance	<p>-For Trail Centerlines: Repeated mowing during growing season</p> <p>- Trailside: depends on species (see above)</p>	- Depends on species (see above)	<p>- Mowing of Trail Center Lines</p> <p>- Trail Edges: Species –specific methods above when location is identified as a pathway of invasion into protected habitat or restoration sites, or if an emergent species. No application should be made within 48 hours of any public access or trail should be closed for 48 hours after application</p>	Irvine Ranch Conservancy unpublished research

APPENDIX A

1996 Signatories to the Central Coastal Orange County NCCP/HCP

U.S. Fish and Wildlife Service
California Resources Agency
California Department of Fish and Wildlife
California Department of Parks and Recreation
California Department of Forestry and Fire
County of Orange
Orange County Flood Control District
Orange County Fire Authority
City of Irvine
City of Tustin
Irvine Ranch Water District
Metropolitan Water District
Southern California Edison
Regents of the University of California
Transportation Corridor Agencies
Irvine Company
Chandis Securities Company
Sherman Foundation
M. H. Sherman Company

2018 Board of Directors of the Natural Communities Coalition

U.S. Fish and Wildlife Service
California Department of Fish and Wildlife
California Department of Parks and Recreation
County of Orange
Irvine Ranch Water District
Metropolitan Water District
Southern California Edison
University of California, Irvine
Transportation Corridor Agencies
City of Irvine
Irvine Company
City of Newport Beach
Public Director – Business

Public Director – Environment

Public Director – Recreation

Coastal Greenbelt Authority (*Ex Officio*)

Orange County Fire Authority (*Ex Officio*)

California Department of Forestry and Fire Protection (*Ex Officio*)

Southwest Resource Management Association (*Ex Officio*)

APPENDIX B

Federal Laws and Other Authorities to which this NROC Integrated Species Control and Habitat Restoration Protocol Conforms

Invasive Species Management

- Executive Order 13112, *Invasive Species*, issued February 3, 1999; revised as Executive Order 13751, *Safeguarding the Nation from the Impacts of Invasive Species*, issued December 5, 2016.
- Plant Protection Act of 2000, 7 U.S.C. 7701 *et seq.* (supersedes all but Sections 1 and 15 of the Federal Noxious Weed Act of 1974).
- Sections 1 and 15 of the Federal Noxious Weed Act of 1974, 7 U.S.C. 2801 and 2814.
- Noxious Weed Control and Eradication Act of 2004, 7 U.S.C. 7781-7786.
- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 U.S.C. 136 *et seq.*
- Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990, as reauthorized and amended by the National Invasive Species Act (NISA) of 1996, 16 U.S.C. 4701 *et seq.*
- Endangered Species Act of 1973, 16 U.S.C. 1531 *et seq.*
- Migratory Bird Treaty Act, 16 U.S.C. 703 *et seq.*
- Bald and Golden Eagle Protection Act, 16 U.S.C. 668-688d.
- National Environmental Policy Act of 1969, 42 U.S.C. 4321-4370f.
- National Historic Preservation Act of 1966, 54 U.S.C. 300101 *et seq.*
- Clean Water Act, 33 U.S.C. 1251 *et seq.*
- Lacey Act, 18 U.S.C. 42 and 16 U.S.C. 3371-3378.
- Alien Species Prevention Enforcement Act of 1992, 39 U.S.C. 3015 & note.
- Federal Land Policy and Management Act of 1976, 43 U.S.C. 1701 *et seq.*
- Public Rangelands Improvement Act of 1978, 43 U.S.C. 1901 *et seq.*
- Carlson-Foley Act of 1968, 43 U.S.C. 1241 *et seq.*
- National Park Service Organic Act, 7 U.S.C. 136 *et seq.*
- National Wildlife Refuge System Administration Act of 1966, 16 U.S.C. 668dd-668ee.
- American Indian Agricultural Resource Management Act of 1993, as amended, 25 U.S.C. 3701 *et seq.*

Pesticide Use

- FIFRA directs federal agencies to use an IPM approach to manage pests. FIFRA states, *“The Secretary of Agriculture, in cooperation with the Administrator, shall implement research, demonstration, and education programs to support adoption of Integrated Pest Management. . . The Secretary of Agriculture and the Administrator shall make information on Integrated Pest Management widely available to pesticide users, including Federal agencies. Federal agencies shall use Integrated Pest Management techniques in carrying out pest management activities and shall promote Integrated Pest Management through procurement and regulatory policies and other activities (FIFRA, 7 U.S.C. 136r-1).”*
- Noxious Weed Control and Eradication Act of 2004, 7 U.S.C. 7781-7786, Subtitle E
- Executive Order 13148 Section 601(a), April 21, 2000, Greening the Government Through Leadership in Environmental Management
- Plant Protection Act of 2000, 7 U.S.C. 7701 et seq. (supersedes the Federal Noxious Weed Act of 1974, except Sections 1 and 15)
- Food Quality Protection Act of 1996, 7 U.S.C.136 (amends both the Federal Insecticide, Fungicide, and Rodenticide Act and the Federal Food Drug, and Cosmetic Act)
- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) 1947, 7 U.S.C. 136-136y
- National Invasive Species Act of 1996, 16 U.S.C. 4701
- Endangered Species Act of 1973, 16 U.S.C. 1531 et seq.
- Occupational Health and Safety Act of 1970, 29 U.S.C. 651-678
- The National Environmental Policy Act of 1969, 42 U.S.C. 4321-4370f
- The National Historic Preservation Act of 1966, 16 U.S.C. 470 et seq.
- Federal Water Pollution Control Act of 1948, 33 U.S.C. 1251 – 1376, Chapter 758, P.L. 845, June 30, 1948, 62 Stat. 1155 (also known as Clean Water Act)
- Animal Damage Control Act of 1931, 7 U.S.C. 426-426c, 46 Stat. 1468
- Migratory Bird Treaty Act of 1918, 16 U.S.C. 701 et seq.
- California Code of Regulations (Title 3. Food and Agriculture)
Division 6. Pesticides and Pest Control Operations

APPENDIX C

Priority Target Invasive Plant Species from NCC Invasive Plant Management Program.

Priority 1: Eradicate reserve-wide. Priority 2: Eradicate in certain sub-watersheds. Priority 3: Control opportunistically.

<i>Species</i>	CommonName	Priority
<i>Aegilops triuncialis</i>	barbed goatgrass	1
<i>Ageratina adenophora</i> [†]	sticky eupatorium	1
<i>Arctotheca calendula</i> (= <i>Arctotheca calendula fertile</i>)	fertile capeweed	1
<i>Cenchrus longispinus</i>	sandbur	1
<i>Cenchrus echinatus</i>	sandbur	1
<i>Centaurea solstitialis</i> [†]	yellow starthistle	1
<i>Chrysanthemoides monilifera</i> ssp. <i>Monilifera</i> [*]	bitou bush	1
<i>Delairea odorata</i> [*]	Cape-ivy	1
<i>Dittrichia graveolens</i>	stinkwort	1
<i>Ehrharta longiflora</i> [†]	longflowered veldtgrass	1
<i>Euphorbia terracina</i> [†]	carnation spurge	1
<i>Euphorbia virgata</i> (= <i>Euphorbia esula</i>) [†]	leafy spurge	1
<i>Galenia pubescens</i>	coastal galenia	1
<i>Hypericum canariense</i> [*]	Canary Island St. Johnswort	1
<i>Iris pseudacorus</i> [†]	yellow flag iris	1
<i>Kochia scoparia</i> [†]	summer cypress	1
<i>Ligustrum japonicum</i> [*]	Japanese privet	1
<i>Limonium ramosissimum</i> [†]	Algerian sea lavender	1
<i>Melinis repens</i> [†]	natalgrass	1
<i>Oncosiphon piluliferum</i> [†]	stinknet	1
<i>Parthenium hysterophorus</i> [†]	Santa Maria feverfew	1
<i>Rubus armeniacus</i> [*]	Himalayan blackberry	1
<i>Senecio linearifolius</i> v. <i>linearifolius</i> [†]	Linear-leaved Australian fireweed	1
<i>Verbesina encelioides</i> [*]	golden crownbeard	1
<i>Volutaria tubuliflora</i>	Moroccan knapweed	1
<i>Ailanthus altissima</i> [*]	tree-of-heaven	2
<i>Araujia sericifera</i> [*]	bladderflower	2
<i>Arundo donax</i> [*]	giant reed	2
<i>Asphodelus fistulosus</i> [*]	onionweed	2
<i>Brassica tournefortii</i>	Sahara mustard	2
<i>Centaurea diluta</i> [†]	North African knapweed	2
<i>Cirsium vulgare</i> [†]	bull thistle	2
<i>Ehrharta calycina</i> [†]	perennial veldt grass	2

<i>Emex spinosa</i> †	spiny emex	2
<i>Glebionis coronaria</i> (= <i>Chrysanthemum coronarium</i>)†	garland chrysanthemum	2
<i>Lepidium appelianum</i> †	hairy whitetop	2
<i>Lepidium draba</i> †	whitetop	2
<i>Lepidium latifolium</i> *	perennial pepperweed	2
<i>Lonicera japonica</i> *	Japanese honeysuckle	2
<i>Nassella tenuissima</i> †	Mexican feather grass	2
<i>Spartium junceum</i> *	Spanish broom	2
<i>Tamarix ramosissima</i> *	tamarisk	2
<i>Cortaderia selloana</i> *	pampas grass	2
<i>Cynara cardunculus</i> †	artichoke thistle	2
<i>Echium candicans</i> †	pride of madeira	2
<i>Ficus carica</i> *	common fig	2
<i>Gazania linearis</i> †	gazania	2
<i>Leucanthemum vulgare</i> †	ox-eye daisy	2
<i>Pennisetum setaceum</i> †	fountain grass	2
<i>Phalaris aquatica</i> †	hardinggrass	2
<i>Plantago arenaria</i>	Indian plantain	2
<i>Robinia pseudoacacia</i> *	black locust	2
<i>Salpichroa origanifolia</i> †	lily-of-the-valley vine	2
<i>Ulmus parvifolia</i> *	Chinese elm	2
<i>Acacia cyclops</i> *	cyclops acacia	3
<i>Acacia redolens</i> *	coastal wattle	3
<i>Albizia lophantha</i> *	stink bean	3
<i>Conium maculatum</i> †	poison hemlock	3
<i>Foeniculum vulgare</i> †	fennel	3
<i>Malephora crocea</i> †	coppery mesembryanthemum	3
<i>Melia azedarach</i> *	Chinaberry tree	3
<i>Olea europaea</i> *	olive	3
<i>Parkinsonia aculeata</i> *	Jerusalem thorn	3
<i>Parthenocissus quinquefolia</i> †	Virginia creeper	3
<i>Ricinus communis</i> †	castor bean	3
<i>Schinus molle</i> †	Peruvian pepper tree	3
<i>Schinus terebinthifolius</i> †	Brazilian pepper tree	3
<i>Tropaeolum majus</i> †	garden nasturtium	3
<i>Vinca major</i> †	periwinkle	3
<i>Washingtonia filifera</i> †	California fan palm	3
<i>Washingtonia robusta</i> †	Mexican fan palm	3
<i>Agave americana</i> †	century plant	3
<i>Atriplex semibaccata</i> †	Australian saltbush	3
<i>Brachypodium distachyon</i> †	purple false brome	3
<i>Carduus pycnocephalus</i> †	Italian thistle	3
<i>Encelia farinosa</i>	brittlebush	3

<i>Eucalyptus camaldulensis</i> *	red gum	3
<i>Eucalyptus sp.</i> *	eucalyptus	3
<i>Limonium perezii</i> †	statice	3
<i>Marrubium vulgare</i> †	horehound	3
<i>Myoporum laetum</i> *	lollypop tree	3
<i>Nerium oleander</i> *	oleander	3
<i>Nicotiana glauca</i> †	tree tobacco	3
<i>Phoenix canariensis</i> †	Canary Island date palm	3
<i>Silybum marianum</i> †	milk thistle	3
<i>Tragopogon porrifolius</i>	purple salsify	3

*Use of systemic herbicides is necessary to achieve control mandates.

†Use of systemic herbicides significantly improves ability to achieve control mandates.

NOTE: Systemic herbicides may also be necessary for other species if population size is too large for manual methods and/or non-systemic herbicides to achieve control mandates.

APPENDIX D

Review of Alternative Weed Control Methods by Irvine Ranch Conservancy

Irvine Ranch Conservancy (IRC) manages approximately 10,000 acres of the NROC under Land Management Agreements with NCCP/HCP signatories, including the lands enrolled by the City of Irvine. IRC conducted several field trials in the City of Irvine Open Space Preserve (a management unit of the NROC) during 2016 and 2017 to test the efficacy of alternative methods of invasive species control for the City's Invasive Control and Habitat Restoration Programs. Any treatment that resulted in single species or mixed stand plant die-off of more than 80% may be considered effective.

Efficacy of Non-Synthetic Herbicide Suppress®

In December of 2016, IRC began researching a variety of non-synthetic herbicides and field testing the efficacy of Suppress®, a City-approved and recommended product for the treatment of young annual and perennial invasive species. Like all the non-synthetic pesticides researched by IRC, Suppress® controls invasive species by damaging exposed plant tissues. Suppress® is an EPA "Warning" label herbicide due to acute hazard to eyes and skin: its active ingredients are Caprylic (octanoic) and Capric acids. Based on label specifications, chemical composition, and experience and field trials from other researchers, Suppress® was expected to be most effective at controlling young, small seedlings with decreasing efficacy as plants age and grow.

IRC established three Suppress® treatment and three (negative) control plots at the Quail Hill restoration site. All plots measured 100 ft² in area and contained approximately equal cover and stature of several common invasive species. The most abundant invasive species on site and within plots were the annual forbs tocolote (*Centaurea melitensis*), filaree (*Erodium spp.*), and black mustard (*Brassica nigra*) and the large perennial forb artichoke thistle (*Cynara cardunculus*). Plants varied from 1-3 inches in height, having emerged only weeks prior following the first seasonal rains. A 5% solution of Suppress® in water was applied as a broadcast spray to all plant material within treatment plots using a backpack sprayer, in accordance with label instructions and precautions. IRC also spot-sprayed Suppress® on invasive species in an additional 1 acre area of degraded habitat within the restoration site. Plots were revisited in early January, approximately 3 weeks later. Plots treated with Suppress® had noticeably less invasive species cover, indicating that Suppress® was successful at killing young seedlings of several species (See Photos 1-4 below). It appeared to be especially effective on small seedlings of annual filaree and tocolote. In contrast, artichoke thistle seedlings within the treatment plots were observed to be unharmed by Suppress®. Further, application of 5% Suppress® on several rosette stage artichoke thistle individuals located in habitat adjacent to

the restoration site was ineffective; plants remained healthy and thriving three weeks post-application.



Photo 1. One of three Suppress® treatment plots at quail hill prior to treatment (12/12/16)



Photo 2. Suppress® treatment plot after treatment (1/4/17). Note contrast w/ area outside plot.



Photo 3. Control plot at quail hill (1/4/17)



Photo 4. Suppress® treatment plot at after treatment (1/4/17). Note contrast w/ area outside plot.

In mid-January, staff spot-sprayed with Suppress® again at the same location to control invasive species at the Quail Hill restoration site. Targeted invasive species included London rocket (*Sisymbrium irio*) in addition to tocolote, black mustard, and annual grasses. Observations one week post-treatment indicated that patches of London rocket were substantially damaged by Suppress® (See photos 5-6 below). However, patches of annual non-native grass were minimally impacted by the treatment (See photos 7-8 below).



Photo 5. London rocket seedlings treated with Suppress® on 1/17/17 (Photo from 1/25/17)



Photo 6. London rocket seedlings treated with Suppress® on 1/17/17 (Photo from 1/25/17)



Photo 7. Disturbed grassland spot sprayed with Suppress® on 1/17/17 (Photo from 1/25/17)



Photo 8. Disturbed grassland spot sprayed with Suppress® on 1/17/17 (Photo from 1/25/17)

Suppress® was also evaluated at the Mule Deer habitat restoration site (Shady Canyon) against a variety of persistent priority invasive species. In mid-January tocolote, black mustard, and the annual grass purple false-brome (*Brachypodium distachyon*) were spot sprayed with 5% Suppress®. Roughly 50% of the tocolote and black mustard individuals were severely damaged or killed by the Suppress® treatment. However, the vast majority of purple-false brome was undamaged or recovered (See photos 9-12 below). Purple false brome is an especially troublesome invasive species in restoration sites as it produces a thick, persistent thatch cover that prohibits native plants from growing through it. Elimination of these invasive species during site preparation and establishment of native plants is essential to successful habitat restoration.

In mid-March of 2017, Suppress® was tested on a roughly 25m² stand (about 150 plants) of flowering garland chrysanthemum (*Glebionis coronaria*) off Mule Deer road. Garland

chrysanthemum has been identified by the Coastal Invasive Plant Management Program as a high priority invasive species for elimination because it is not yet widely distributed but can spread readily and dominate once introduced to new areas. The stand was treated with a 9% solution of Suppress®, the highest recommended concentration for mature plants according to the manufacturer's label, using a backpack sprayer. Suppress® was effective at killing approximately 50% of the treated plants; the other 50% recovered in subsequent weeks and continued to flower, retaining the ability to produce seed and spread further. Photograph #13 below is of a flowering garland chrysanthemum three weeks after treatment; note dieback and subsequent re-growth.



Photo 9. Purple false brome grass treated with Suppress®.



Photo 10. Purple false brome grass treated with Suppress®.



Photo 11. Black mustard and tocolote treated with Suppress®.



Photo 12. Black mustard and purple false brome treated with Suppress®.



Photo 13. Re-growth of garland chrysanthemum Plant following initial Suppress® damage.

To evaluate the effectiveness of Suppress® on more mature invasive species, IRC returned to the Quail Hill site in early May and marked and sprayed several dozen individual plants of scarlet pimpernel (*Anagallis arvensis*), bristly ox-tongue (*Picris echiodes*), tocolote (*C. melitensis*), Russian thistle (*Salsola tragus*) sweet fennel (*Foeniculum vulgare*), and artichoke thistle (*C. cardunculus*). Observations were made on May 18th to photograph and document effectiveness. Control of these species with Suppress® was highly variable among species. Tocolote again seemed to respond the most to Suppress® treatment, however only approximately 50% of the plants were killed or severely damaged. The other annual invasive species treated, specifically bristly ox-tongue, black mustard, and scarlet pimpernel, were marginally controlled (less than 25%), with the majority of plants appearing to have either recovered (healthy re-growth evident) or not noticeably affected by the treatment (see examples below). The two perennial species treated, sweet fennel and artichoke thistle, were observed to be unharmed by the treatment as was the annual Russian thistle (see Photos 14-21).



Photo 14. Bristly ox-tongue (*Picris echioides*) recovering 18-days after being treated with Suppress® herbicide.



Photo 15. A damaged bristly ox-tongue plant following Suppress® treatment.



Photo 16. A recovering scarlet pimpernel (*Anagallis arvensis*) plant following Suppress® treatment.



Photo 17. A damaged scarlet pimpernel plant following Suppress® treatment.



Photo 18. A recovering (*Centaurea melitensis*) tocolote plant after Suppress® treatment.



Photo 19. A damaged tocolote plant following Suppress® treatment.



Photo 20. Sweet fennel and Russian thistle uncontrolled by Suppress®.



Photo 21. Sweet fennel and Russian thistle uncontrolled by Suppress®.

Based on the results of these trials and from applications of Suppress® earlier in the season, IRC has concluded that Suppress® is variably and only marginally effective at controlling priority invasive species and most annual invasive plants commonly found in habitats in the Open Space Preserve. It may still be useful for certain invasive species and certain applications, and is generally most effective when applied to young annual invasive species or seedlings of certain species, particularly forb species (non-grasses). As annual forbs mature, however, they recover more readily from any initially sustained damage. In contrast to annual invasive species, several perennial species were observed to be minimally affected by Suppress®, even when applied at the maximum label dosage. Further, most non-synthetic herbicides operate in the same way as Suppress®, by damaging exposed plant tissues, and would almost certainly produce similar results here. Our research with other land managers shows similar results with other brands.

Since Suppress® is the most highly recommended of these non-synthetic compounds, IRC did not believe that field tests of other similar brands were warranted.

Unfortunately, many of the invasive plant species deemed most noxious and threatening to native habitats are perennial species or persistent annuals with complicated life histories and prolific reproductive capabilities, which makes them extremely difficult to control. Suppress® was not effective at controlling the perennials artichoke thistle and sweet fennel, two of the most abundant and problematic invasive plants in the NROC which contribute significantly to habitat degradation over time. This result was not surprising, considering the mechanism by which Suppress® controls plants. Suppress® destroys the plant tissues it comes in direct contact with and has minimal impact on a plant's root system. For many of the most difficult invasive species, and artichoke thistle in particular, the root systems are quite deep and extensive. With the root system intact, perennial plants readily grow new leaves and above-ground tissues, not unlike their response to a single manual cutting of stems and leaves. From IRC's long-term experience controlling artichoke thistle manually using sharpened shovels to cut plants, it takes several treatments per season for multiple years (as many as seven total for each individual plant) to finally exhaust the plant's stored resources and kill it.

Testing and Efficacy of Manual Control

As a matter of practice and consistent with IPM policies, IRC integrates manual control techniques wherever possible to address annual and perennial invasive species. IRC's field studies (IRC, unpublished data) as well as those from other land management practitioners (e.g. DeSimone 2011) have shown that repeated cutting of artichoke thistle rosettes at four to six week intervals over the course of two years will eventually kill plants, as long as sufficient labor is available to consistently maintain treatments. The cost of labor to employ this technique can be significant compared to chemical control. Similarly, a basal root cut with a shovel twice per season or more has been shown to work over two years. Both techniques have been employed with some success since 2008 in easily accessible areas such as trailside in Quail Hill. In areas off trail with considerable other vegetation, these techniques are problematic as it may be very difficult to locate treated plants for multiple cuts.

It should also be noted that basal root cuts disturb soil and have been demonstrated to stimulate germination of additional artichoke thistle plants from the seed bank, and to provide establishment opportunities for disturbance-loving invasive species such as Russian thistle, which may remain dormant for many years in soil. In 2017, IRC expanded multi-cut manual control techniques on a trial basis to include all high priority artichoke thistle populations in remote areas. These populations were prioritized because they are likely to spread into

surrounding intact healthy coastal sage scrub and grassland habitat. IRC subcontracted field crews from American Conservation Experience (ACE) for several weeks during the 2017 growing season, who hand-cut approximately 35,000 artichoke thistle plants across the Open Space Preserve.

Although initial cuts on mature plants were easy, subsequent cuts were unexpectedly difficult for laborers because rosettes could not be readily found amidst other spring growth. In fact, ACE estimated that up to 50% of field time spent in later cuts was expended searching for previously cut individuals, even though they had been marked. IRC concluded that both because efficacy was reduced and because of the potential damage to native habitat of multiple visits (as well as the creation of informal trails by laborers), multiple cuts are not appropriate for remote areas where most of the artichoke thistle occurs. Some species were observed to be controlled effectively by manual removal, including Sahara mustard, bull thistle, garland chrysanthemum, young trees such as castor bean and tree tobacco, and highly visible and trailside accessible artichoke thistle. All these species were observed to be most effectively controlled by manual removal when their populations were small and less dense.

With the exception of easily accessible populations of certain species (e.g. trailside), the reduced efficacy of manual control for many applications and increased labor also comes with a significantly higher cost. IRC considers increased costs to be significant when effective control cannot be achieved within the established fixed cost budgets of its Land Management Agreements. In 2017, the cost of the Invasive Control Program and Habitat Restoration Programs in the City of Irvine using mechanical means combined with non-synthetic herbicides (at reduced effectiveness <80% compared to prior years) was approximately \$120,000 greater than the annual management funding provided in the Agreement. The City partially supplemented this funding on a one-time basis. IRC contributed \$24,000 of its own funding and in-kind labor to do the work in 2017.