Review of Three Dirca Species

With

Special Emphasis on D. Occidentalis

Jasper Ridge Biological Preserve
Docent Research Report

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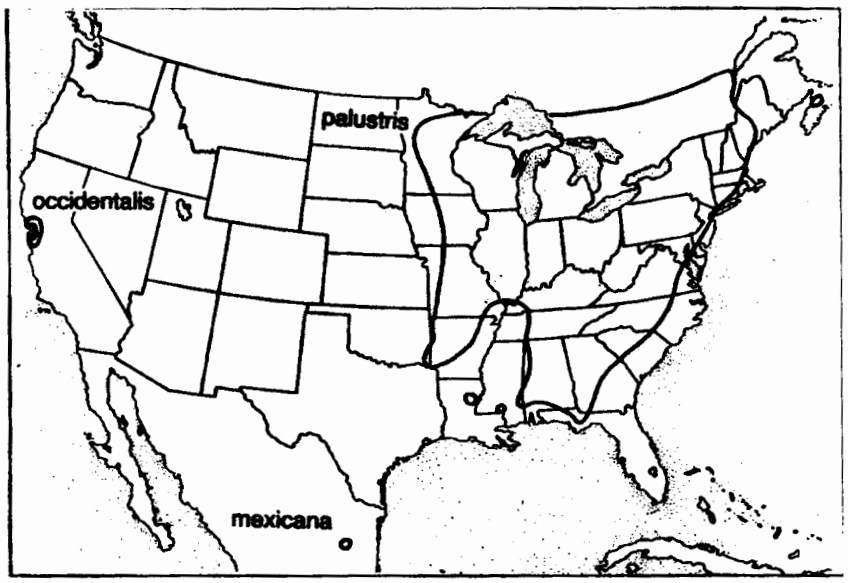
Background

Dirca occidentalis Gray (DO), or, Western Leatherwood, was first identified in 1873 by Asa Gray, in Oakland, California. "Dirca" refers to a mythical spring near Thebes; occidentalis refers to the western habitat.

DO is defined as a Category 1B endangered shrub by the California Native Plant Society (18), CNPS. Species on the 1B list are rare and judged to be vulnerable. Most have declined significantly over the last 100 years. They must be protected as prescribed by the California Environmental Quality Act, although DO is not listed as endangered under Federal regulations.

A second species exists over a wide-range of the Eastern United States. This species is called D. palustris, DP, or Eastern Leatherwood. "Palustris" refers to a boggy or wetland habitat. A third species was discovered in 1995. This species is D. mexicana, or DM.

The map below, from Nesom and Mayfield (11), shows the widely disjunct species locations. DO is located in the San Francisco Bay Area in Alameda, Contra Costa, Marin, Sonoma, San Mateo, and Santa Clara Counties. While well-represented at Jasper Ridge Biological Preserve (JRBP) and present in 5 other Bay Area counties, it has not been found elsewhere in California. DP locations are spread over more than 20 states. Although DP has a considerable range, it is also not an abundant species. DM was found in one limited area of the Sierra Madre Oriental in Tamaulipas, Mexico.



For his Docent Research Project, in 1995, Holl (8), identified locations of DO on many trails of JRBP. He also recorded associated shrubs, trees, and other features of the DO habitat. He tested the hypotheses that DO requires California buckeye to be present in its habitat. He concluded this hypothesis is not true and suggested additional research topics.

In this work, *Dirca* refers to all 3 species collectively. Individual species are identified as DO, DP, or DM.

Why study Dirca?

Before starting my training to be a docent, I had never heard of Dirca. What I learned early on intrigued me:

1. A previous study had been done on DO at JRPB, which provided an opportunity to build on that study.

2. DO begins blooming as early as November and December, ahead of most other plants. So there was an opportunity to begin my research project early. The shrub would be relatively easy to find and observe from flowering to ripened seeds through the 5 month docent class that began in January.

3. While DO is endangered in California, it is plentiful in 6 Bay Area counties, including JRPB, and therefore represents a unique study opportunity.

4. Since mapping locations at JRBP with the GPS unit remained to be done, a project on DO provided the opportunity to walk all the trails and fire roads of JRPB, to gain familiarity with the preserve, as well as learn how to use the GPS unit.

5. Since DO not only has a disjunct filial species in the East, which I learned early in the study, it has a third related species, also disjunct and discovered in 1995, which added a new dimension to the study.

6. Curiosity was fed by the lack of information I could find in the literature about basics, such as pollinators, propagation, toxicity, predators, and more for all Dirca species.

Objectives

The purposes of this project were initially not as broad or in the order shown below. As the project became more opened-ended, Cindy Wilber (docent program coordinator) suggested I provide a comprehensive overview rather than perform an individual research project. Hence, I sought to:

1. Perform library research on the various species of Dirca and build a bibliography of material on all species of Dirca.
2. Develop a network of parties interested in all species of Dirca.

3. Finish the mapping effort that Holl et al have accomplished since 1995 using GPS.
4. Analyze the favorable reproduction of DO at JRBP.
5. Evaluate propagation methods of DO in the horticultural community.
6. Determine conditions that support DO growth, including at other Bay Area locations.
7. Identify future research opportunities with DO.
8. Compare all 3 species.
9. Share the results throughout the network.

Conclusions

1. In the case of all 3 species there remain *many open questions* not answered by the literature. Traits which have been defined for one of the species create avenues of inquiry for the other two species.

2. Rules about DO habitat should be interpreted as tendencies. In the field you will find exceptions, but the tendencies are strong enough to predict off-trail locations:

    a. Figure 1 shows DO locations at JRPB. The "trail" population estimate is *900-2200 plants*. There are many more plants in areas not accessible from trails. All trails and fire roads have been GPS'd.

    b. The shrub prefers *mesic* situations on *N and NE-facing slopes* but can be found in other slope situations. The underground status of the shrub (availability of water, etc,) can only be inferred from the above ground conditions unless one disturbs the soil or roots, which I have not done.

    c. Fog in the Bay Area, and the maritime effects on temperature, may substitute for summer rains in the East, and this is an oft-stated hypothesis, which I found no reason to try to refute. DM was also found on a steep, north-facing slope, on a mesic cove surrounding a rocky watercourse, although other details of climate were not discussed.

    d. The subject of *required* associations with other species of plants, shrubs, trees or pollinators, is intriguing. While I would love to hit on the right formula for co-evolution of any other species with DO, given the "discovery" of co-evolution at JRBP, I believe there are no such *required* associations:

        DO will grow quite successfully without California buckeye, but *buckeye probably does provide something in nature that DO needs*: a *low enough canopy to provide enough sunlight*. Other deciduous trees can provide this environment, but an environment of shrubs with no trees is also an environment where DO can thrive.

        One could hypothesize an association with California bay laurel, as proposed to me by more than one observer. *Bay laurel association is not*

necessary. Bay certainly seems to favor moist environments. However, a mature bay can create a high, dense canopy which seems to preclude DO growth. Sometimes DO is found with immature bays, but as the bay mature, the DO becomes spindly and recedes. Indeed, buckeye and bay will both die or not grow in settings where taller evergreens cause a dense, dark canopy.

Whether a mycorrhizal association exists is uncertain. This association is not addressed in the literature. Again, disturbing the soil and roots, plus having access to a lab, is required to follow-up on this.

3. The make-up of the *canopies for the other Dirca species is nominally quite different but functionally similar*, ie, deciduous trees of varying heights.

4. *"Deep", dark canyons of redwood and fir are not conducive to DO growth.* If one visits the deeper locations along Hamm's Gulch Trail or the Lost Trail/Razorback Ridge Trail at Windy Hill Preserve, one sees no DO (or buckeye, and one can encounter bays toppled due to apparent root insufficiency). Those same trails at higher elevations contain all of these species. The Sylvan Trail at Edgewood Preserve contains very few DO; the topography is similar to JRBP, but I got the impression that it is a darker trail than at JRBP. All of these are public parks, so the degree of disturbance of the environment always needs to be determined. *The relative absence of "deep', dark canyons at JRBP, where the topography could be described as "rolling" and where the highest elevation is about 200 m. could explain the greater population at JRBP.*

5. *DO does not appear to grow in permanently standing water*, although I have seen seasonal exceptions to this near the intersection of Trails 10 and 12. DP is recommended as a "swamp" shrub in N. Carolina, although in that case (39) DP is described as growing in temporarily but not permanently standing water as well. One could postulate negative water-related associations, such as "DO will not grow where willows grow because those situations are too wet". So far, I have not seen exceptions to this hypothesis, although Trail 12 would be the candidate. The description of the location of DM is consistent with this.

6. The *life span of DO is 50 years or so.*

7. There is *evidence that DO thrives in disturbed areas.* DO will thrive if canopies of surrounding trees are reduced, eg, through a tree fall; it will also sprout from roots/crown if cut to the ground; it has been reported to bounce back after cattle grazing; and it often exists in trail switchbacks where the canopy is more open. Coincidentally, DM was found along a road, and the presence of large stumps suggested prior logging. Therefore, *logging history in the Bay Area 150 years ago, during the Gold Rush, could be a factor in reinvigorating the local population of DO.*

8. *Survival of Dirca in fire has not been documented in the literature.* The ability to sprout from the crown suggests survival in fire is possible.

9. *DP seems to thrive in denser canopies* than DO or DM, based on the literature.

10. Biogeographic analysis suggests *Dirca was a single species at some time*.

    a. Distribution could have been across the US at one time.

    b. The disjunction between east and west could have been caused by movement of continental plates and subsequent climate changes or by ice age impact. Evolution of the more Mediterranean climate in the west could have lead to the demise of much of the western Dirca population.

    c. Geological movement of continental US territory in a southerly and westerly direction could account for the presence of Appalachian-like species in NE Mexico.

    d. I would not be surprised if there are Euro/Asian species as well.

11. The existence of two other species of Dirca, in apparently different climates and in different associations than exist at JRBP, shows evolution in action. In the West, summer fog may substitute for summer rains in the East, and this is an oft-stated observation, but one wonders how the species' survives in the Sierra Madre Oriental during 100 degree F summer heat. Canopies for the 3 species are each comprised of different trees and shrubs.

12. Pollination by diurnal species is VERY infrequently observed for DO at JRPB:

    a. People familiar with DO, DP, and DM doubt that airborne pollination is likely due to the absence of large quantities of pollen and the physical structure of Dirca flowers.

    b. *The fact there are likely insect pollinators for DP and DM suggests DO is also pollinated by insects, possibly nocturnal.*

    c. *Bat pollinators are unlikely at JRBP, since none of the 11 species identified at JRPB are nectar eaters.*

    d. *DO may have outlived its natural pollinator.*

13. N*o seed dispersal mechanisms are defined for any of the species*. Efforts to identify dispersal of DP seeds have shown no significant dispersal by birds (Schulz, pers comm); evidence in that research is that rodents may be the vectors. However, the period in which seeds remain on the ground after falling from a shrub is short, so evaluation is difficult. Others, like Nevling (pers comm.) are adamant that DP must

be disbursed by birds to account for its distribution post the impact of glaciation (20,000 yrs ago).

14. DP toxicity, in the form of contact dermatitis and GI distress, has been reported; children have reportedly died from ingesting DP seeds (27-36). Toxicity for all species is not clearly defined. *It is possible that bark, leaves, roots, and/or seeds in all species are toxic* in some portion of their life cycles. It is not clear to what degree contact must occur. *Toxicity may influence herbivory and seed dispersal.*

15. *Cold stratification of seeds* is apparently part of the seed cycle in nature. It is in 2001 definitely part of the horticulturalists' approach for both DO and DP. This has been relatively unsuccessful, so the full understanding of seed propagation is not at hand. No other pretreatments (eg, mycorrihizal inoculation or acid soak) have been identified.

16. *Propagation from roots has not been proven for any of the species*, and propagation from stem cuttings has not been achieved where tried (DO, DP). DO has been observed to re-sprout if the shrub is cut to the ground. Whether it does so in other conditions of stress or part of the normal reproductive cycle has not been shown. Young plants in the "shadow" of older plants could be either from seeds or root propagation.

17. *Dirca in all species is slow-growing*. Understanding why populations are larger in one location compared to another depends on understanding the relative environments over extended periods (50+ years).

18. *The 3 species respond to their different climates by blooming at different times*. DO begins to bloom in November and December and continues into March. DP begins its bloom more in May. DM has been observed one season and its bloom was then in March. The rest of the plant cycle is adjusted accordingly, depending on climate.

Discussion

Literature Search and Network.

Appendix I is a bibliography of published papers and Internet locations. There is a wide range in quality among these citations. Some are from reliable sources (eg, the FDA) but incomplete, and some are simply anecdotal at best. Even scientific research papers may have been surpassed by subsequent discoveries. All are included.

I did not start with species' comparisons or a biogeographical review in mind. I was hoping to find whatever was published on DO as a guide to what kind of field research I might do that would be an addition to the understanding of DO. I found less than I hoped on DO. In fact, if one searches on "Dirca" alone, one is able to find more on DP by far. Before the literature search, I was not aware a third species exists. There is only one published paper on DM.

After the literature search, I bombarded the authors and anyone else I could find with emails and phone calls. The literature search and subsequent personal communications provided the information needed to do a comparison of the 3 species. The section below entitled "Species Comparisons" provides morphological comparisons and sketches from the literature.

The full network is listed in Appendix II. A side-by-side comparison of the 3 species is provided in Appendix III.

I did not find adequate answers for Topics 4 (reproduction of DO), 5 (horticultural success), and 6 (reasons for rarity). I was able to develop horticultural sources through the network, and the network was particularly helpful in identifying local sites of DO. The network was also quite useful in identifying research-in-process, mostly on DP.

Biogeography

I accepted the biogeographical conclusions of Nesom and Mayfield (11). They subscribe to the "simplest hypothesis that it (DM) belongs to the floristic element with its closest evolutionary ties to the flora remaining in the southeastern United States, the geographic continuity between them probably established, as in Graham (5), during the middle to late Miocene. The disjunction between D.palustris and D. occidentalis may be considerably older, according to Graham (6, 7), as a vegetation probably including these species was spread across North America through much of the Tertiary, beginning as early as the Eocene." For those of you who don't carry these arcane period references at your fingertips, please be reminded of the following, from younger toward older:

Cenozoic Era (age of recent life)
- Quaternary Period (3 M years ago) ←Last ice age about 20000 yrs ago
  - Holocene Epoch (1 M years ago)
  - Pleistocene Epoch (3 M years ago)
- Tertiary Period (66 M years ago)
  - Pliocene Epoch (5 M years ago)
  - Miocene Epoch (25 M years ago) ←SE US & Latin American
  - Oligocene Epoch (50 M years ago) linkage (DP and DM?)
  - Eocene Epoch (60 M years ago) ←DP and DO across N.A.?
  - Paleocene Epoch (66 M years ago) ←Modern continents formed

Mesozoic Era (age of medieval life beginning 240 M years ago)
- Cretaceous Period (138 M years ago)
- Jurassic Period (205 M years ago) ←Pangea still intact as single continental land mass
- Triassic Period (240 M years ago)

Paleozoic Era (age of ancient life)
- Etc: seven more periods beginning with Cambrian (570 M years ago)

Precambrian: The time between the birth of the planet and appearance of complex forms of life. More than 80% of the Earth's estimated 4.5

billion years falls in this era.

Alternative explanations are possible in matters of biogeography. Nesom and Mayfield refer to Axelrod (2), a well-known expert in this area of interpretation, but they chose Graham's interpretation of history instead. Axelrod was not specifically addressing the distribution of Dirca but was instead looking at causality for Mediterranean climate species in areas ranging from Euro Asia to the western US. He stated "...the closely related disjuncts found in eastern Mexico, the Appalachians, and the West coast of the US represent remnants of a continuous forest earlier spread into Mexico and more simultaneously fragmented as a result of a spreading dry climate in the mid-Oligocene."

Nesom and Mayfield argue their case by saying, "Many eastern NA disjuncts were present in eastern Mexico by the middle Pliocene, and global paleotemperature history suggests that cooling in the middle Miocene may have been an appropriate time for their principal introduction." (What's missing here is a clear articulation of the timing of cooling trends, various ice ages, and the impact on the flora. For further follow-up, see App. I, ref 44A for an ice-age tutorial, 44B for the Atlas of Paleovegetation, and 44C for references on the Holocene as well as links to The Quaternary Research Association and Paleolimnology)

Figure 2 below shows the globe and the continents as they might have appeared in the Early Tertiary period according to Axelrod. There is a hypothetical linkage between the Mediterranean area in Europe/N Africa, the SE US, and SW US that this drawing illustrates as the Madrean and Tethyan regions formed.

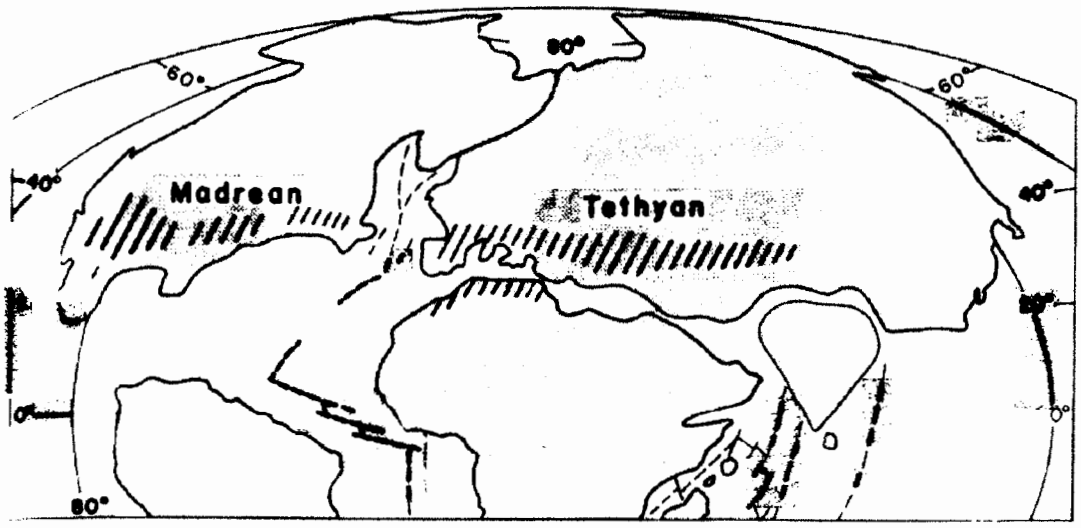


Figure 2

The linkage from the Appalachian Belt to Mexican lands is shown in another way by Figures 3 A and B below:

A

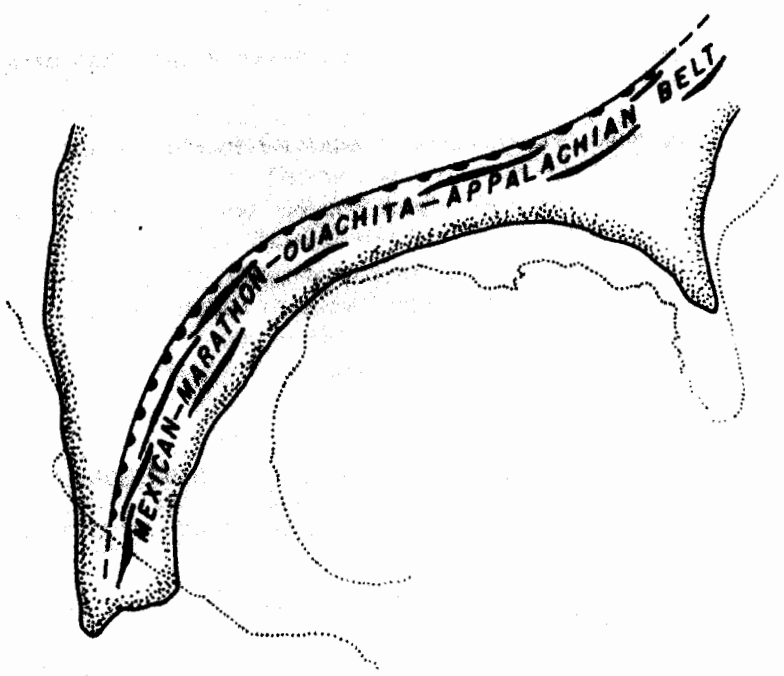


Figure 3 A

B

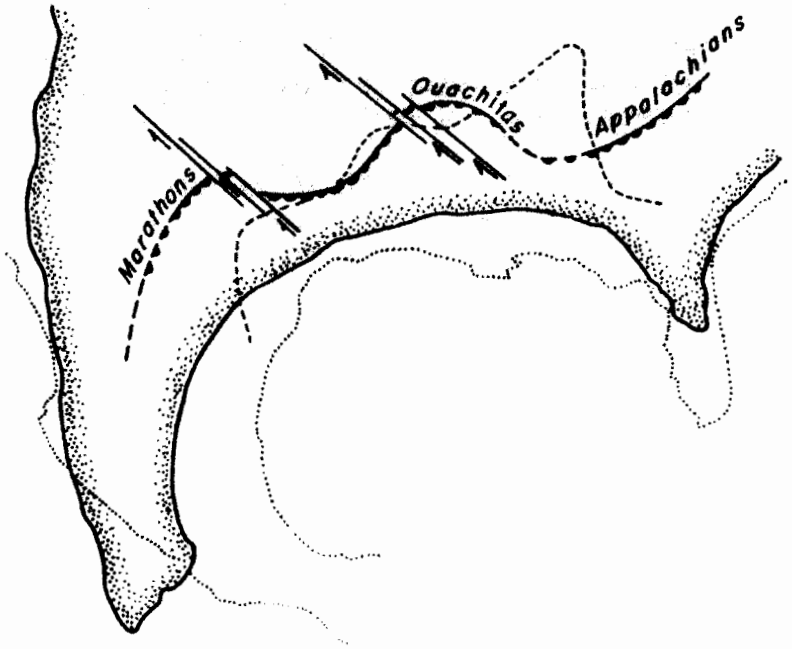


Figure 3 B

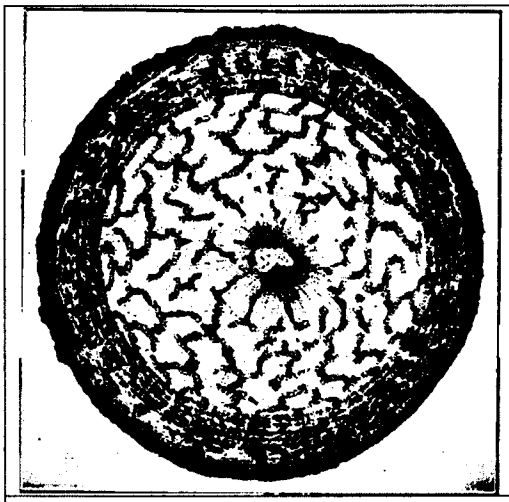
This land movement is suggestive of how DP and DM may well have been more closely related in the past, although **extensive physical comparison of the two species (below) shows DM to be more like DO, in contrast to this biogeographical conclusion.**

Axelrod (2) also makes brief reference to DO as being "arcto-tertiary" in origin (another unclear reference). This led one person (Himes, pers. comm.) to speculate, biogeography aside, that DO, as a relict species, has very possibly out-lived its natural pollinator.

Species Comparisons (See Appendix III and discussion below)

The primary sources of comparison of species are Nesom (11), Vogelman (16), and Zasada (17). There are photographic images available as well (18-24).

The great flexibility of leatherwood, in all species, led to uses by Native Americans, to exploit this flexibility. This is captured in the photomicrograph of DO shown in Figures 4A and 4B below, which is a transverse section of a 6-yr old DO stem.



←4 A

Figure 4A shows the C- or S-shaped arrangement of zylem vessels.

4 B→

This is followed in Figure 4B by an enlargement of an inner portion of that segment, with the center of the stem in the upper left corner. The hollow circles are xylem vessels; the radial spaces are wood fibers; the inner circumferential layers are wood parenchyma; and the radial lines are xylem

The source of this photomicrograph is McMinn and Forderhase (10). In the opinion of those authors "...the great flexibility of stems and branches would be accounted for by

the C- or S-shaped arrangement of the narrow bands of xylem vessels, by the radial arrangement of the wood fiber cells and the thinness of their walls, and by the terminal position of the wood parenchyma cells and the thinness and cellulose nature of their walls."

I found two DO, about 1 ½ m. tall that had accidentally been cut down. I counted 20 "rings" in each stem cross section. These specimens had been dead several years and had become brittle.

DO Compared to DP

The original published comparison of DO and DP was in 1953 by Vogelman (16) and was based on extensive analysis of preserved specimens. Those species (and DM) share a "...yellow, tubular-infundibuliform corolla-like calyx with 8 stamens alternately long and short, inserted inside the tube. The stile is filiform. At the base of the flower are 3-4 hairy bud scales which form an involucre." The most common flower grouping for each is 3.

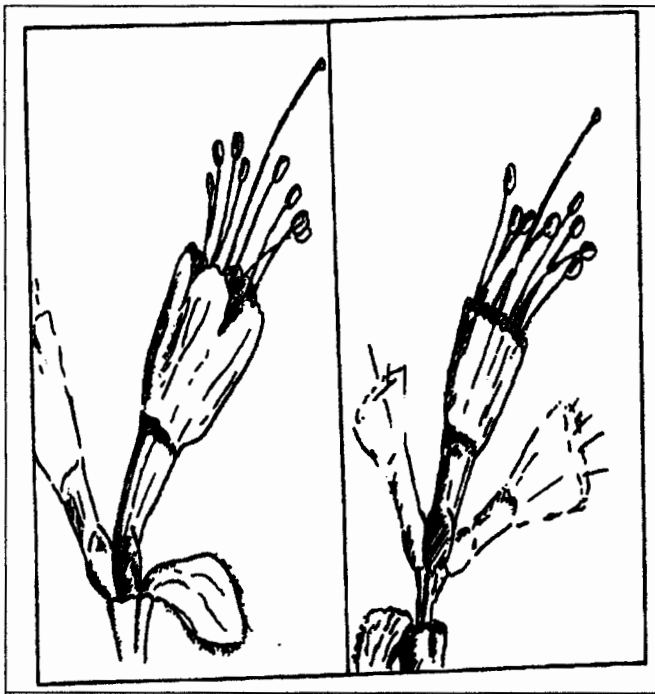
The key which summarizes these observations is shown here as Table 1:

Bud scales with whitish pubescence; flowers and fruits sessile; calyx distinctly 4-lobed, sinus 1-2 mm deep; stamens inserted in proximal half of calyx-tube; mature leaves sparsely covered with whitish pubescence on lower surface, current year's twig growth often with whitish pubescence.....DO

Bud scales with dark-brown pubescence; flowers and fruits pedunculate; calyx with wavy, obscurely toothed margin, not cleft; stamens usually inserted in distal half of calyx-tube; mature leaves and young twigs glabrous.....DP

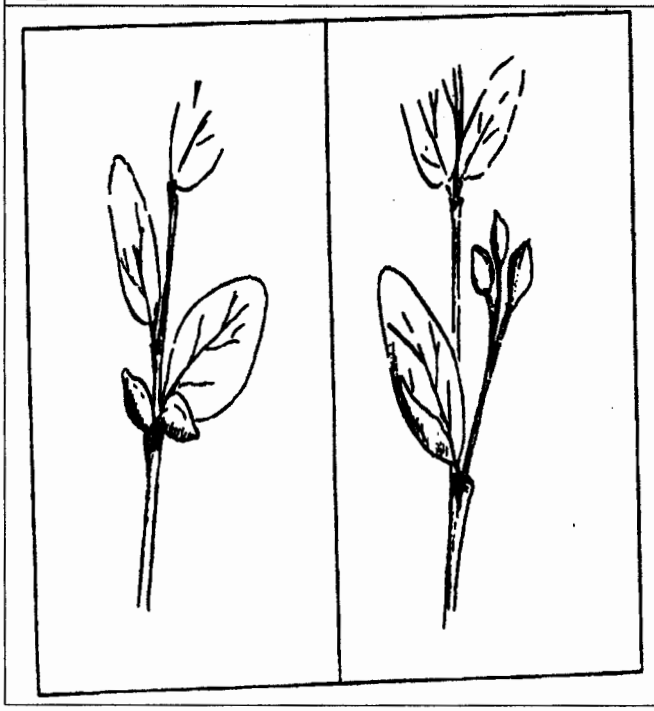
Table 1

Figures 5 below from Vogelman shows the major differences in DO and DP morphology that had been previously recorded in various herbaria sheets.



← 5A

You will see here most notably the 4-lobed fascicles of the DO flower on the left in contrast to that of DP on the right



←5 B

The leaves have differences as well. DO leaves on the left are oval with a rounded base, while those of DP on the right are narrow at the bases.

You will also see the pedicel of DP is "so short at anthesis that it can easily escape detection. However, after the fruit has set, the pedicel and peduncle elongate (up to 20 mm)".

Figure 5

This was further supplemented by dimension tables, which I've included here as Table 2: (the **bold** numerals represent larger averages)

	DP		DO	
	Ave	Extremes	Ave	Extremes
Calyx-tube				
Length	6.63mm	5-10mm	**8.23mm**	6-10mm
Width	2.22	1.5-3	**3.88**	1.5-5.5
Insertion of Filament from Distal end	3.09	2-4	**5.08**	4-6
Filaments				
Long	5.15	3-7.5	**8.08**	6.5-11
Short	4.56	2.5-6.5	**7.34**	4.5-11
depth of attachment of filament rel to length	0.46	0.37-.60	**0 .62**	0.55-0.85
Leaf				
Length	**72.7**	45-100	50.5	40-69
Width	**43.5**	25-65	31.8	25-42

Table 2

DM Compared to DO and DP

Nesom and Mayfield (11) compared all three species, here shown in Table 3:

1.Bud scales with dark-brown pubescence; flowers and fruits pedunculate; calyx with wavy, obscurely toothed margin, not cleft; Eastern US.....DP

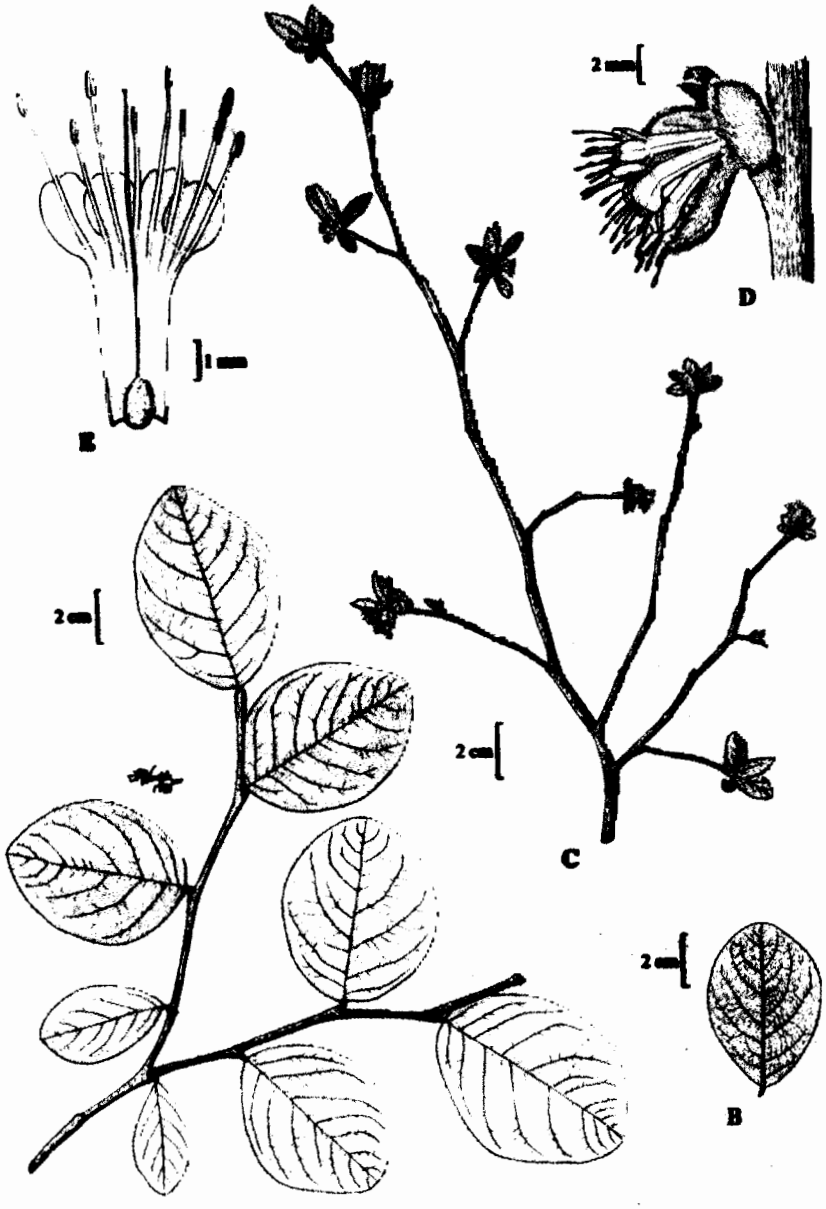
1.Bud scales with whitish pubescence; flowers and fruits sessile; calyx distinctly 4-lobed, sinus 1-2 mm deep; SF Bay region in US or NE Mexico.....(2)

2. Calyx tube **2-4** mm long, broadened into a broadly funnelform limb **4-6** mm long (**additive dimensions**); staminal filaments inserted below the middle of the calyx, anthers exserted 3-4(-5) mm above the flower at maturity; SF Bay region.....DO

2.Calyx tube 5-7 mm long, abruptly broadened into a flaring limb 2-4 mm long; staminal filaments inserted above the middle of the calyx, anthers exserted 2-3 mm above the flower at maturity; style and stigma about level with the anthers at maturity; Sierra of NE Mexico.....DM

Table 3

Figure 6 below provides Nesom and Mayfield's sketches of DM:



Habitat Comparisons

In Appendix III there is a section that shows the relative habitats of Dirca species. The commonality of factors is interesting despite the different species of associated trees and shrubs, which exist in each of the habitats.

It should be emphasized that DM has only been noted in one location, 2500 km from the nearest DO and 1100 km from the nearest DP. That one location is identified by Nesom and Mayfield (11) as Arroyo Obscuro on 35 km of road from Sta. Engracia to Dulces Nombres. There were an estimated 800-1000 plants over 300 m in open canopy microsites, singly and in clusters. All generalities about DM are based on this single site observation. The authors stated they could not identify features, which accounted for the rarity of the plant, and in fact noted other locations, which appeared similar along this road but contained no DM. Evidence that logging had occurred in the area did exist.

Toxicity and Chemical Analysis

The published reports of toxicity are limited to mostly anecdotal observations related to DP. These are documented in the bibliography in a dozen places. The number of references is misleading in the sense there is very little that is systematically reported. In fact, when I mentioned the possibility of contact dermatitis from DO to experienced docents at JRBP, the response was "I handle the stems, as well as leaves, all the time to show the flexibility of the species and have never had a problem."

The importance of this could be more significant to why deer appear to leave DO alone and how seeds are dispersed. So far, the published literature is almost totally silent on this subject, which is odd for a potentially endangered species such as DO; indeed, all 3 species are of limited abundance where they appear.

Suggestions as to the types of toxicity are as follows:

1. DP is listed as "poisonous" by at least two governmental agencies including the FDA (see ref 27, 29), but adequate specificity (leaves, bark, seeds?) is lacking.

2. Anecdotal descriptions of dermatitis, blistering, and sores due to contact with DP are mentioned in others (ref 28, 31, 32, 34), but what exactly has to rubbed or cut for this to occur is unclear.

3. DP seeds would appear poisonous throughout at least part of their life cycles (see ref 30, which says that DP seeds are quite irritating and will definitely give you a stomach ache). The science in these observations is short of a controlled clinical trial (see ref 31, where American Mezeron, suggested to be DP, is described: "30 berries are used as a purgative by Russian peasants, though French writers regard fifteen as a fatal dose". "The berries have proved fatal to children.") Perhaps this is a different species in the Euro-Asian areas.

3. Chemical analysis reported in the literature was fragmentary:

a. For DO, extracts, and possible chemical synthesis, has occurred (see ref 3, 15) for use in models for anti-cancer activity. In these papers, the source of the DO material was not described nor were the extracts tested on humans.

b. Chemical analysis of DP has identified the following:

   i. biologically active phenolic glycosides (see ref 12), specifically obtained from winter dormant twigs that were lyophilized, milled, and extracted sequentially with hexane, ethyl acetate and methanol. These extracts were used in models to determine COX-I and COX-II (anti-inflammatory) activity, ie, the objective was to determine potential pharmaceutical activity not toxicity (phenol is a caustic, poisonous white crystalline compound, C6H5OH derived from benzene and used in resins, according to dictionary.com);
   ii. calcium oxalate crystals in the stem (oxalic acid is a colorless organic acid found in many plants, according to dictionary.com; and,
   iii. diuretic qualities without a description of the diuretic agent.

4. Again, for American Mezeron (ref 31), "Acridity of the bark is chiefly due to mezeen, a greenish-brown, sternutatory, amorphous resin." Root bark was stated to be worse in effect than stem bark.

5. DM toxicity was not discussed, and this shrub has not been observed past the flowering stage.

6. In a note from Nevling (pers com) he stated the "fruits are likely poisonous as are the fruits of almost all Thymelaeaceae...some are used as purgatives in native peoples and some plant parts are used as fish poisons. The compounds are coumarin related...I really haven't heard anyone complain of contact dermatitis with DP".

This could be a fruitful area of research.

Locations and Quantity of DO at JRBP; GPS Work

One objective at the outset of this study was to complete previously started location work, to establish an estimate of the population at JRBP, and to identify the pollinator for the shrub. There was a premise there is a lot of DO at JRBP, so a question lurking in the background was "Why?" The quest for the unidentified pollinator and an even more global question of reproduction at JRBP for a plant known to be endangered prompted me to do a literature search. That broadened the scope beyond my expectations.

Figure 1 above is a composite of data taken by multiple numbers of people. The original data were collected in 1995 by Holl (8) before GPS was available at JRBP. There were no quantitative estimates in the 1995 data. The GPS data are entered as "one, 2-10, 11-20, 21-50, and >50." Ackerly (1) and his students also collected data, including location,

phenology, and morphology data. Luckily, there is pretty good overlap with GPS measurements done by others with the 1995 locations.

Because of technical problems this season with the GPS unit during the time when only DO is blooming and easy to identify (Jan-Mar), I focused on doing locations not previously done or where historical data were ambiguous. Between 1995 and the present, some trails were developed or enhanced (eg, Trails b and c and the extension of Trail 2). Now, all trails and fire roads shown in Figure 1 have been surveyed.

The summation of low ends and high ends of the data ranges, rounded, yields an estimate of 900-2200 DO at JRBP. For the >50 category, 75 was used as the upper limit on any observation. Dirca grows slowly, living an estimated 50 years, possibly longer (17), so unless a way is found to estimate populations not on the trails, this representation of populations, though clearly not perfect, could suffice for 5-10 years.

My numerical estimates of DO at JRBP have "poison oak" and "trail" bias. I would occasionally follow deer trails that I thought would lead me to DO (the best markers are other DO, low canopies, and N or NE-facing moist slopes). In addition, the protocol noted above is not a census but rather an estimate.

There are some very logical spots for more DO to be residing in JRBP based on Figure 1, and there easily could be more in a given location than were counted from the trail. On the other hand, there is a possibility that some DO shrubs are nearer the trails, such as in the areas of switchbacks or trail maintenance, simply because the presence of a trail results in the canopy being lower than it might have been.

By plotting the data on a vegetational, topographic map I was hoping to show patterns. There are exceptions, so consider these as tendencies. DO:

1. favors N and NE-facing slopes; I have found it on S and SW-facing slopes;

2. likes moister (mesic) environments;

3. does not like dense canopies. Buckeye often provides a favorable canopy, but buckeye is not a requirement. Bay trees, Ca live oaks, and deciduous oaks can be found often with DO, provided the canopy is not too dense, but as these trees grow in height and density, DO is likely to get more spindly and fragile. If one finds a high, dense tree that has fallen over, and if there were DO present under that canopy, the DO will have a resurgence of growth and vitality;

4. does not stand out in the middle of a grassland where coyote brush can thrive but can nevertheless be found in chaparral, without any trees at all, in the company of coyote brush, holly-leaved cherry, toyon, ceonothus, and poison oak. All of these can be taller shrubs than DO, but they do provide a low overall canopy.

Ackerly's draft report (1) supports the idea that DO has certain tendencies, but one needs to be cautious in over-generalizing: "It was the sixth most frequently encountered shrub species, and it had a bimodal distribution on the insolation gradient. The lower mode corresponds to individuals found on cool, north-facing slopes, while the higher mode reflects local concentrations on hilltops. These plants were found in the shade of taller shrubs (e.g. H. arbutifolia) and seemed to be concentrated at the interface between the north- and south-slope vegetation. The abiotic factors promoting survival of Dirca on hilltops are not known. In a preliminary study, soil moisture levels on hilltops were found to be intermediate between the moister north-facing slopes and the exposed south-facing slopes (H. Schoonover and N. Dumont, unpublished data) and do not explain these local occurrences. Recent studies have found surprising evidence that chaparral shrubs are quite sensitive to freezing-induced embolism, and infrequent frosts can severely damage plants (Boorse *et al.* 1998; see Tyree *et al.* 1994). This damage is more severe in low-lying areas, due to the down-slope flow of cold air at night. Freezing-induced embolism is also more severe in plants experiencing water stress. We suggest a possible explanation for Dirca's occurrence on hilltops is that it may be sensitive to freezing damage. It is therefore protected on hilltops, and on north-facing slopes where it is well-hydrated, on cold nights. This may also explain Dirca's relictual distribution around the San Francisco Bay, where the strong maritime influence results in the some of the mildest winter temperatures in central California. Experimental studies to test this hypothesis could provide valuable information pertinent to the conservation of this endemic species." (See JRBP weather data, App I, ref 46.)

DO shrubs vary in vitality. As suggested above, they appear to weaken as the canopy thickens. One is left to imagine what the conditions were when the shrub began its growth. In addition, "vibrancy" is intended by me to extend to quantity of seed production:

1. The best production I have observed is where good exposure to the sun exists. The shrub is denser when it gets more sun, and the seed seems to set higher in number. Nonetheless, climatic factors over the preceding winter or spring, before blooming and seed set, may be more important. Seed set does not guarantee a fertile seed. Furthermore, research on DP found only a weak correlation with light availability. In fact, this research found "inflorescence production per shrub was relatively stable from year to year (+-25%), but fruit production varied by a factor of five. Fruit production appears to be greater in alternate years. '95 and '97 were low years; '96 and '98 were high years." See ref (17A). If this is any guide, one needs to be extremely careful in variable selection and controls.

2. There has also been research into stem growth increments, shoot characteristics, and leaf characteristics for DP in relation to light availability to evaluate the effect of canopy harvest on shrub success where logging occurs. Growth chronologies for 5-25 years showed transient periods of growth consistent with light gap formation. However, this was limited to leaf mass not shoot and other leaf characteristics. See ref (12A).

I have observed some nearby locations of DO (courtesy of Bilisoley, Greene, Himes, Johnson, and Robert Young, pers comms):

1. Edgewood Park. I found only a few shrubs on the Sylvan Trail. This trail is about 2.5 miles long and those I found were only about a half mile from the end. These shrubs are sparse in numbers and virility.

2. Rancho San Antonio Park. There are numbers of DO shrubs on the Wildcat Canyon Loop Trail. This trail contains both more and less dense portions. I recall being in evergreen fir, redwood, etc portions of the trail where no DO is obvious, but at higher elevations and in switchbacks I found DO flourishing. There are many trails one could walk there, and it would not be surprising to find more DO on them.

3. Windy Hill. I walked up Hamm's Gulch Trail toward the top of Windy Hill. At the lower levels, it is much too dense to grow DO. As the trail climbs gradually toward the summit, one eventually encounters DO, especially in several places where switchbacks in the trail occur. On trail switchbacks, the canopy is often lighter than the surrounding area. On this day, I chose to walk down from the ridge via Lost Trail and Razorback Ridge Trail. My total hike was 9.6 miles. There were a few DO shrubs evident on the return route but not many. Again, one stood out because it was in the middle of a switchback. On other days, I have walked Spring Ridge Trail and Sausal Trail at Windy Hill, neither of which have DO that I could see.

4. Los Trancos Rd off Alpine Rd. About 1mile from Alpine is Oak Forest Rd to the right. Beyond that, on both sides of the road, are DO for about ½ mile. There is a requirement to reduce the fire fuel load along Los Trancos Rd because of the development called Black Oaks. Some of these DO were cut down by the developer, whose consultant said in the EIR there were no DO visible. Local residents intervened, marking DO with pink ribbons. Based on my observations at JRPB, this DO will do well as the residual canopy is more favorable and competition has been greatly reduced.

Local populations I have been told about but have not seen include:

1. locations in San Mateo County Parks near Crystal Springs Reservoir; Pulgas Ridge off Edgewood Road in Redwood City, Stevens Creek Park in Santa Clara County;

2. populations in Marin County;

3. Lake (letter) provided me a CNPS (East Bay Chapter) listing of locations in Alameda and Contra Costa Counties. She also noted (email) there are larger populations specifically in Tilden Park (Berkeley), Chabot Regional Park (Oakland), Redwood Regional Park (Oakland), Siesta and Gateway valleys east of Caldecott Tunnel near Orinda (mostly on E Bay Municipal Water District (EBMUD) property, small populations at Hucklberry Regional Preserve (Oakland) and a fair-size population in Carquinez Straits Regional Park (Crockett), the farthest north population on the east

side of the bay that she knows. She personally counted 1240 plants at EBMUD. The EBMUD site is a place she has seen 'regeneration'(but not stump sprouting per se). She has handled DO leaves, but not bark, and experienced no negative reaction. In darker canopy areas, the shrubs disappear eventually. The best and largest populations are on N and sometimes E facing slopes, often in coast live oak/bay forests. Rarely does she see plants going to fruit and setting seed.

4. In addition, Lake (letter) provided me a 1982 report by a student, Tang (15A), for the Tilden Park/Strawberry Canyon (Berkeley) area. As part of the report, there is a map of locations provided. This report makes the following declarations:

a. There are two vegetative reproductive mechanisms: sprouting from the base of the stem by damaged plants and rhizome/creeping roots, with stems rising from that. This latter mechanism was more characteristic of particular localities (rocky soils, trampling, and browsing). (Tang's writing style is such that one does not clearly know if he is speculating or these are actual observations of cause and effect. I observed sprouting from the base of sheared stems but never definitive rhizome structures.)

b. DO does not produce nectar (Nesom made a similar statement about DM.)
c. There are relatively few pollen grains per anther. The pollen grains are "relatively large, 70-80 microns". This, and the small stigma surface area suggests wind pollination is unlikely.

d. DO was able to reinvade an area after grazing. DO reproduction seems to be aided by disturbances. (I observed reinvigorated DO growth after tree falls had occurred.) It does not do well in dense areas (I agree.).

Interestingly, there are no reported DO at Hastings Natural History Reservation in Monterey County according to Stromberg (pers comm.). (Santa Cruz and Monterey Counties are the next counties south of the "Bay Area".) This site has precipitation data back to 1928, with data on temperature and hours of sun from 1938. North facing slopes comprise about 40% of this preserve. The basic information would seem to be available to determine why DO is not present.

The issue of fog in the Bay Area and the influence of moderate maritime temperatures are topics I did not pursue. (See App. I, ref 44D, for a tutorial on fog.)

As one watches DO evolve through the early part of a season (Jan-May), one sees the vibrant green leaf color give way to a more distressed-looking green and yellowing under apparent heat stress. There should be data germane to this issue within Ackerly's work (1), in which relative abundance, leaf size, and leaf thickness of a number of species was monitored as a function of slope aspect.

There is a certain amount of "mine is bigger than yours" I've encountered in doing this population study. Questions like "Why is there so much DO at JRBP?" imply there is a lot relative to somewhere else. Or there may be something unique here that could lead to a commercial opportunity, since the horticulturists have not really come up with commercial quantities for landscape purposes. It is possible there may be a need for this kind of statement as support for funding of some future study. This claim made for a population outside of JRBP may even be useful in combating a developer who may otherwise destroy a truly unique stand of DO. So population counts probably are useful for more than bragging rights.

Pollinators

In addition to the question, "Why are there so many Dirca at JRBP?" the other question most often asked is "What is the pollinator?" After have walked all the trails and fire roads, probably twice, looking for Dirca, I have seen a grand total of 4 European honeybees nectaring on 3 different shrubs. I have also seen a few ants wandering in the vicinity of fascicles and occasionally entering them, presumably to nectar. I have seen one hummingbird hover close to a shrub and then move on. I have spoken to one person in the network (Bilisoley, pers comm) who has observed hummingbird's nectaring on the Los Trancos pod of DO, whereas others (9) support the notion that hummingbirds have little interest in DO. I would observe:

1. Nectaring does not prove pollination is occurring. The stamens of DO are quite extended ('exserted') from the fascicles (1/4-3/8") as shown above. The honeybees I observed could easily not have come in contact with the stamens or pistil, due to the physical demands of nectaring compared to pollinating.

2. I can't rule out nocturnal pollination. Eleven bat species that have been identified by studies at JRBP, but none of these is a plant pollinator (Mudd, pers. comm). Nocturnal insects could be at work. Since there seems to be so few pollinators out in the early season when DO blooms, there would have to be a marked difference in populations of nocturnal pollinators to make them into effective pollinators.

3. Airborne pollination would be an easy explanation, but the odds are against it. DO certainly does not produce visible pollen clouds as would be suggestive of airborne pollination. And the plant does virtually all of its blooming during the rainy season; this would lower the odds of success. And some argue the physical arrangement and size of the pistil and anthers are not conducive to airborne pollination (ref (15A), Heiple (pers comm.), Nevling (pers comm.), and Schulz (pers comm.).

4. Papers on DP (13) state that species is monoecious, and presumably so is DO and DM, although I'm not sure that drives one conclusion or another about pollination.

5. DP blooms in a period where there are lots of lepidoptera to pollinate it, which is what is presumed to be occur (Shulz, pers comm.); would or could evolution make DO that different?

6. DM appeared to be pollinated by at least one species of bee and 4 species of butterflies, according to Nesom and Mayfield, but no nectar or fragrance was observed by them despite attempts to identify them.

7. Nevling (pers com) stated "DO occasionally has a microlepidopteran leaf miner..."

Propagation by Other Means

The literature (17) makes categorical statements that Dirca, whether Western or Eastern, cannot be propagated from stem/branch cuttings. Propagation from root cuttings may be possible; at least I haven't disproved it. In nature, I've seen numerous instances of either sprouting from the crown or from underground roots. This is most visible on Trail 9, on which DO and other shrubs have been cut to the ground as part of periodic trail maintenance. This only suggests root cuttings might work. While there seems to be a common belief that DO propagates from the roots, if one sees new growth underneath an older DO, one simply cannot tell whether it is sprouting from a seed or from the roots of this (or nearby) shrub. Lake and Heiple (pers comm.) and Tang (ref 15A) all believe some sort of vegetative reproduction occurs, whereas Nesom (11) discounted this for DM and DO.

Seed Dispersal

DO seeds should ripen by June but probably not before this paper is due. I know it is possible to find populations of DO that are remote from others, (such as the one near Goya Gate), so one is left wondering how they got there. Propagation by roots would not answer the question in that case. Most populations of DO have multiple members, as one can see from the data, but that does not eliminate root propagation. One does observe that where the canopy is dense, seed formation is low or nil; the question then is will the shrub propagate by roots in that circumstance, or is it simply conserving energy to keep the plant alive by neither producing seeds nor new shrubs via root sprouts.

As to dispersal by birds or rodents, this needs an experiment. From the literature (23-32), DP seeds are toxic, at least to children, where deaths have been mentioned. GI problems occur in adults. In some states, DP plants are considered poisonous, but these listings are ambiguous (poisonous if you eat what? or is reference being made to contact dermatitis, which has also been documented?) Is there a poisonous period for the seeds and a ripe, non-poisonous period? And, of course, are human problems extrapolatable to animals? One observes virtually no herbivory on DO, at least from the time the flowers bloom followed by the leaves, until the time of this writing. That is not conclusive either.

Horticultural Attempts at Propagation

Yerba Buena Nursery on Skyline specializes in native plants. There are several graduates of Yerba Buena still accessible, and I have also visited the current propagator at Yerba Buena. The current success at Yerba Buena is "perhaps two shrubs a year" by seed (Dye, pers comm.). The methodology is to cold stratify seeds for several months; cold

stratification is in a refrigerator at about 39 degrees F for several months, in a bag of moist vermiculite. Sprouted seeds are transferred to other containers, where most of the losses occur (Dye, O'Brien, pers comm.). East Bay Biological Preserve (Johnson, pers.comm.) was successful with about 100 plants about 15 years ago but not since. His approach included the same cold stratification approach. I called numerous other nurseries and possible sources specializing in natives without finding any highly successful current propagators (33-39).

The literature on DP specifies cold stratification and then sowing at 70 degrees F (17). Yields are not good, although I have seen pictures of DP used as a yard shrub in Eastern settings. DP is also supposed to do best in soil of pH 6-7 to alkaline (38).

You can see from this that something is missing in the formula. One might speculate on the need for inoculation of seeds with mycorrhiza, other pretreatment of seeds, other cold/warm cycles, some special soil treatment, etc.

Additional Studies Required (with special reference to DO at JRPB)

The objective of a consultant, the cynic might say, is to establish a need for additional studies. My objective was to find hard conclusions, but the consultant could only admire my result.

I am hopeful it is possible henceforth to narrow the focus of DO research, since the literature search, population mapping, optimal conditions for growth, and network have been moved forward another notch. More remains for DO and Dirca generally:

1. Further evaluation of N/NE facing aspects could be done. Ackerly (1) has shown characteristics of N/NE-facing slopes, ie, cooler temperatures. Elevation of locations on such slopes might be a factor. Most DO, but certainly not all, tends to be on the lower parts of the slope, unless the canopy gets too dark. The down hill part may be the warmer or colder part of the slope in different seasons. One anomaly is the population of DO near Goya gate, near the mowed path I identified as Trail 17a on Figure 1. This is a gently sloping N/NE facing area with no canopy, at 170-180 m in elevation; it could be the most exposed of the DO populations.

2. Propagation from root structures could be assayed from the population that is periodically "mowed" on Trail 9. If one assumes some of these shrubs will eventually be lost, the risk of doing root excavation work on one of these plants is minimal. I am also aware of private stands of DO within the Network where such experimentation might proceed.

3. In Kasada et al (17) the production of flowers and seeds for DP was reviewed. For DO, this could be a function of sunlight. This could be measured with a light meter throughout the day in various locations. This kind of single-variable, single season study is dangerous, however, given the possible influence of other variables through the dormancy period, through this season's growing period, or even last season's.

Given the variation in flower production (+-25%) v seed set (5x) observed from season to season with DP, one would need to be cautious in choice of variables observed.

4. Pollination by nocturnal pollinators or self-pollination has a higher probability due to the absence of visible diurnal pollinators. Airborne pollination (cross-pollination) is less likely but has not been clearly dismissed.

5. Optimal conditions for growth may be debated. I can envision a study, in addition to the one I mentioned above for flower productivity, which measures leaf production/leaf canopy of the DO shrub as a function of environment, particularly sunlight.

6.The question of "What is the right soil composition?" or water content is unaddressed here, but a future researcher would need access to a soil lab. There is a recent geological map of JRBP (see ref (17B) that could be used as a starting point for soil types, although I personally do not know enough about this subject to know how useful that reference might be.

7. The general question of why DO is so plentiful at JRBP is, I'm convinced, a combination of the number of N and NE-facing slopes, a low enough canopy, the "right" temperature, and moisture supply. One can see along Hamm's Gulch Trail at Windy Hill, for example, or places in Rancho San Antonio Park, the taller evergreens in the lower elevations have eventually eliminated the shorter species, like buckeye, and sometimes each other, as bay trees succumb to a too-moist, too-dark environment.

- The proportion of N/NE facing slopes could be quantified at JRBP. The proximity of seasonal water flows, temperature, and fog, could be linked with this. Work has been done on this topic by Dumont and Schoonover (4A), although I have been unable to retrieve this paper to review it.

- A proxy is possible DO locations. The quantity of buckeye species could certainly be tested as a canopy proxy. I have examined aerial photos of JRBP in June of several years and believe there is the potential for differentiating buckeyes in bloom and in early stages of dropping their leave in those photos. (Buckeye is drought deciduous and begins dropping leaves in June.) In addition, there are similar photos in November and December for several years; this is a time of year when buckeyes would be leafless and could be used as a confirmatory measure of buckeye location. If this is combined with topographical maps for aspect and water flows, one could be able to identify potential DO locations. In the best of all worlds, these could be compared to other locations in the Bay Area with similar climates to further test hypotheses. These interpretations could be compared with known locations of DO to test the model.

8. The literature search I did ascribes the population of DO in the 6 central California counties to the presence of the summer fog in those counties. This needs to be evaluated.

9. As the season progresses, water stress becomes more evident in the plants. This could be analyzed, perhaps, if humidity and soil moisture measurements could be obtained. Other related phenomena occur in summer fog areas, like more moderate temperature. Our proximity to the ocean and the bay help to moderate our temperature year-around. DP has evolved to be less dependent on our degree of moderation, and the conditions for DM would seem further modified. Again, Ackerly's (1) research techniques could be very helpful in pursuing this question.

10. The absence of DO at Hastings could also be analyzed in view of extensive weather data available in that relatively nearby environment.

11. The toxic qualities of DO, and all Dirca, need to be established: leaves, bark, seeds, flowers, and roots in various seasons and degrees of exposure need to be evaluated. The impact on herbivory assuming toxicity exists needs to be judged.

12. More complete and accurate DO population studies at JRPB would require:

a. Refinement of the protocol: 2-10, 11-20, 21-50, >50.
b. Estimating of all regions by a single person or team.
c. Development of ways to measure off-trail regions via proxies or poison oak desensitization. I have studied Figure 1 and suggest, based on aspect and water flows, the following candidate locations, independent of canopy (see 9 above for further thoughts on canopy evaluation)

Down slope north of Trail c.
Down slope east of Fire road F toward the eastern border of JRPB.
Down slope north of Trails 3 and 4 toward Trail 1.
Down slope north of Trails a and 5 toward Trail 1.
Down slope north of Trail 9 toward seasonal waterway that drains to SE portion of lake.
Down slope west of San Francisquito Creek toward Bear Creek on a trail which is currently not identified.

13. The quantity of nectar within the flowers needs better elucidation in view of ambiguity on that subject in the literature.

14. The general issue of how to grow DO, or Dirca in general, in a nursery setting could be pursued further. I have raised issues relative to mycorrhizal association. Or alternative stratifications could be tried. I recently was told by a JRBP docent that poison oak seeds will not sprout unless they have traversed the gut of a predator, suggesting pretreatment of DO seeds with acid or other "gut" chemicals may be necessary. In view of the general lack of knowledge of predators on Dirca seeds, this becomes more intriguing.

Research "In the Mail"

An assiduous reader of Appendix II will see there is research underway this season, abstracts of papers not yet published, and research I was unable to source at Stanford, all of which is "in the mail". For simplicity, I'll list these research inputs here:

1. Nona Chiariello, the Scientific Director at JRBP, has one colleague who did not respond to an inquiry about a possible mycorrhizal association. Nona worked in this field as a graduate student, which I discovered during the literature search. She is following-up with another colleague.

2. Kurt Schulz has several unpublished papers that have been presented at the Ecological Society of America and other venues in years past. I recently received these abstracts and have tried to incorporate these observations above and in Appendix I. (Kurt was also nice enough to offer me the opportunity to visit the DP sites in the Upper Peninsula of Michigan in May during bloom. This location is being monitored by Zasada and Schulz. I was unable to make this trip.)

3. John Zasada was a co-author of a paper on the phenolic glycosides in DP. The journal in which this paper appears is not kept at Falconer Library. Schulz has also recently provided me a copy of this paper. See ref (12).

4. Lorin Nevling was on his way to China for a month when I made first contact with him. There is more follow-up possible with Lorin. See Nevling in Appendix II for detail on the many subjects that interest him in this regard.

5. There are several professors doing work on DP. See Schulz and Williams (this season). Also Anderson and D. G. Brown (in Appendix II) have high interest levels but have not as yet done research on DP.

6. The work of Ackerly et al, and Dumont and Schoonover, is all relatively new to me and in various draft forms or not yet found. Their observations on DO are part of broader studies. For example, Ackerly, commenting on Dumont and Schoonover, stated "...the data set you collected is not too small for statistics. I did a quick ANOVA and there is a significant interaction between exposure (north, ridge, south) and hill, i.e. the pattern differs on the two hills, as you can see. If you remove the interaction term then the exposure term is significant, but looking at the data the interaction does seem to be the relevant pattern. There is no effect of depth in the soil (a little surprising since all but one sample was greater in upper layer." (Note: Ackerly has been on sabbatical during preparation of this paper.)

7. At least one person in the network, Heiple, has lived in areas with DP and currently lives in the Bay Area (see both Appendix I and II). He could be helpful, in addition to Shulz and Zasada, mentioned in 2 above, with DO and DP comparisons if a JRPB researcher were able to visit them.

8. Contact was made with Graves (see Appendix II) in August. He is tentatively planning to visit Mexico and DM next spring. I have offered to help him with research he may conduct.

Next? When I made observations I thought were particularly interesting during this research, I sent emails to a group of JRBP people I hoped to entice as possible Dirca Detectives. I solicited assistance from docents at Edgewood Preserve, horticulturalists, members of the California Native Plant Society, and many authors of papers I found. I also made contact across the US with people familiar with DP and with the discoverers of DM. My intent is to give this report to those who have shown an interest in commenting. Hopefully, an on-going network of people will critique my work, share ideas and data, and continue future research.

There remain many gaps in the knowledge level of all 3 Dirca species. Some of the conceptual studies suggested here may apply to the other species. DM was not studied beyond the flowering period by its discoverers in 1995 (11), and there have been no other published studies. As noted, reproduction studies have not been published for any of the 3 species. Toxicity data are anecdotal for DP and non-existent for the other two species.

The knowledge mosaic for Dirca is partly filled in, but there remains a substantial portion of the mosaic for you to pursue. Imagine the interesting challenge of such an effort: 3 disbursed species in North America with representation possible in Euro/Asia as well.

Appendix I May, 2001

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15A Tang, Willie "Observations on the Western Leatherwood Dirca Occidentalis (Thymelaeaceae) I Strawberry Canyon and Tilden Park" 1st Draft 6/3/82 (for Prof. Ornduff)

16 Vogelman, Hubert "A comparison of Dirca palustris and Dirca Occidentalis". Asa Gray Bulletin. N.S. Vol.II, No.1, Winter, 1953 pp 77-82.

17 Zasada, John et al "Dirca palustris L." A chapter in the Woody Seed Manual, currently under revision. Found on Internet when searched for "dirca" via Google.

17A Zasada, Schulz et al Poster 2000 Annual Meeting of the Ecological Society of America, August 5-10, Snowbird UT "Flower and fruit production in DP..."

Illinois State Academy of Science 92nd Annual Meeting April 7-8, 2000, Augustana College. "Flowering, Fruit Set, and Fruit Production in DP"

Maps

17B Coleman, R. G. "Geologic Map of JRBP Area", 1997, Stanford Geologic Survey

Internet Locations

Specimen Images

18 www.cnps.org/rareplants/inventory/definitions.htm Defines 5 lists for categorizing degrees of concern. This site also defines the R-E-D Code (Rarity, Endangerment, and Distribution, with 3 subsets for each)

19 mobot.mobot.org/cgi-bin/search_vast Missouri Botanical Garden specimen list Contains location data and images of D.M.

20 www.stanford.edu/~rawlings/kengif/flower.htm Picture of D.O. taken at JRBP

21 elib.cs.berkeley.edu/cgi/img Will get you to a dozen images of D.O.

22 bioweb.wku.edu/faculty/ameier/shantyhollow/shanty2 Will get you 4 images of D.P.

23 scisun.nybg.org:8890/searchdb/owa/wwwspecimen.search_search/list?taxon=Dirca+ NY Botanical Garden--also contains D.M.reference but no images

24 mexicana+(

Descriptions/Overviews

25	www.friendsofedgewood.org/newsletters	See Buckout above.
26	www.britannica.com	The order Thymelaeales is described. D.P. is mentioned. The comment is the "order is distinguished by bisexual or separate male and female flowers". I do not believe this is true for Dirca.

Toxicity (this section has a low scientific content, but you are not going to want to rub yourself with, or eat, Dirca)

27	USFDA Poisonous Plant Database	lists DP as 'poisonous' but is not specific
28	www.gardenbed.com/D/4570.cfm	GardenBed.com. Sells D.P. Warns of severe dermatitis with redness, blistering and sores in some people.
29	www.ces.ncsu.edu/depts/hort/consumer/poison	"Poisonous Plants of North Carolina,"Dr Alice B. Russell, Department of Horitcultural Science, et al. 1997. D.P.
30	www-personal.umich.edu/~lszabo/favorites	D.P...."escaped the onslaught of deer browsing in Michigan's Western Upper Peninsula due to its high lignin composition." "...fruits are quite 'irritating' and will definitely give you a stomach ache."
31	www.botanical.com/botanical/mgmh/m/mezere	American Mezeron is the name for D.P. Lists habitat as Europe, incl. Britain, and Siberia. "Acridity of the bark is chiefly due to mezeen, a greenish-brown, sternutatory, amorphous resin."..."Stimulant and vesicant..will cause redness and blisters in 24-48 hours" "Root bark is most active but inadequate supplies led to the recognition of the stem bark also." "30 berries are used as a purgative by Russian peasants, thought French writers regard fifteen as a fatal dose." !! "The berries have proved fatal to children"
32	archive.uwcm.ac.uk/uwcm/dm/BoDD/	Botanical Dermatology Database, University of Wales, College of Medicine "Applications of the fresh bark to the skin causes redness, vesication, and sores which are very difficult to heal (Dispensatory 1884)
33	www.homeoint.org/clarke/d/dirca	A Dictionary of Practical Materia Medica by John Henry Clarke, MD "colic,constipation, cough, debility, diarrhea,dyspepsia,affections of eyes, flatulence,headache, affections of heart, neuralgia, rheumatism" Doesn't sound as if based on a controlled clinical trial!!!!!!
34	www.biosurvey.ou.edu/shrub/dirc-pal.htm	Oklahoma Biological Survey. "Fruits may be narcotic. May cause dermatitis." "Dirca refers to a mythical spring near Thebes; palustris refers to the plant's boggy or wetland habitat."
35	emuseum.mnsu.edu/cultural/ethnoarchaeology	Medical uses of D.P. according to MN source. "stalk was cut up, dried, pulverized. It was steeped in warm water and drank(sic). It was used for the physic. Root mixed with mugwort used to wash hair and make it grow." !!!!
36	ibiblio.org/london/alhealth/herbal-references	Southwest-School-of-Botanical-Medicine/database Again refers to American Mezereon

Horiticultural/Landscaping/Nurseries

37	members.aol.com/gstigall/calret.htm	California Native Plant Sources. Lists nurseries dealing in native plants.
38	www.anet_chi.com/~manytimes/p.64.htm	How to sow DP seeds. "3m @39F, move to 70F for germination"
39	ncstate	Qualifiers for Quagmires: Landscape for Wet Sites
40	www.extension.umn.edu/distribution/horticulture	soil condition for DP slightly acid (pH6-7) alk (>pH7); poor drainage
41	msue.msu.edu/msue/imp	MI State Extension:DP in "ordinary" soil but may be used in moist soil
42	ME Native Plants	DP in light: S; moisture M;
43	www.easternplant.com/main.asp	Eastern Plant Specialties. Sells DP. Located in ME. "...fascinating plant that really does have bendable stems...VERY rare and difficult to find & sought after. Carefree in sun to half shade."

Miscellaneous

44	www.biodiversity.uno.edu~gophtax/_gophtax.98/0274	Taxacom Listserv Archives (misnomers) at UWGB.edu "DP implies a swamp habitat, but it is strictly a rich mesic species"
44A	www.museum.state.il.us/exhibits/ice_ages	Ice age tutorial
44B	www.soton.ac.uk/~tjms/adams4.html	Atlas of Paleovegetation
44C	www.ucmp.berkeley.edu/quaternary/hol.html	The Holocene:a discussion of that period plus linkages to the the Journal of Paleolimnology and the Quaternary Research Assn.
45	www.users.csbsju/~dgbrown/	Associate Professor D. Gordon Brown, to be doing study of plant/animal interactions w/DP
46	http://jasper1.stanford.edu/research/sitedata/climate.html	JRBP weather data

Citations not Retrieved

While reviewing my notes, I came across several interesting citations I apparently did not look up. I'll document them here, because they look germain to the topics I have reviewed:

Axelrod. "Fossil plants from SF Bay region". In Geologic Guide to the NorthCoast Ranges, Point Reyes Region, CA Geol. Assoc. Sacramento Guidebood pp.74-86

Raven, Peter and Daniel I. Axelrod, Origin of the California Flora, Botany, v 70-73, 1976-1978. (#72 specifically). This must be the citation used by Himes in his telephone conversation with me.

"History of the Mediterranean ecosystem in CA. Evolution of Mediterranean Ecosystems. In F. di Castri and H. Mooney (eds.), p 225-277. 1973.

Personal Communications (see Network, Appendix II for more detail on addresses, etc)

Ackerly, David	See network	David communicated several points via Nona Chiariello: see below. Also trying to locate Dumont and Shoonover paper.
Anderson, Greg	"	Still interested but has not done more with DM or DP (email 4/25/01) Greg was a participant in the 1995 trip to Mexico with Nesom et al.
Bilisoley, June	"	June reviewed experience on Los Trancos Rd. Also pointed me toward Paul Heiple, who has led tours of DO locations on the Peninsula (telecon approx 3/22/01)
Brown, Gordon	"	"...interested in studying the pollination and see dispersal of DP in our area (central MN). Has a colleague in chemistry that I'm trying to get to do some work on Dirca phytochemistry..." (email 4/18/01)
Brown, Irene	"	Several helpful emails on data gathering and possible people to whom to talk and possible pollinators (emails 2/12, 13, 27). In the latter email, Irene speculated there must be some way to recover from fire as well. Also gave reference to Microbial Ecology, by Atlas and Bartha, which gives a good overview of mycorrhizal associations. I also found reference here to Nona C's work as a graduate student.
Buckhout, Stephen	"	Cross-reference to Himes (email 2/20/01)
Chiariello, Nona	"	Did work on mycorrhizal associations back in 1982. Out of touch now. Has an acquaintance, Matthias Willig, who could help. Mentioned using the search engine at Los Alamos National Lab and not finding anything on DO mychorrhizal associations. (email 3/16/01). Willig did not respond. Nona to try others. Also clued me into work by H. Schoonover and N. Dumont (unpublished) on soil moisture; also emails to Schoonover and Dumont from Ackerly suggesting the role of location in protecting DO from freezing, speculating that hilltops are warmer on freezing nights. (email 2/16/01).
Cohen, Philippe	"	Met 4/30/01 to review what might be possible in identifying buckeye locations There are June aerial photos for 98, 99 that look as if they may be useful for buckeye I Ds. There are also Dec 2000 photos which could be compared to April or June photos as a way of separating out buckeye, since there are also Apr 96 and 97 photos. (more possibilities exist--these are the only photos I examined) Be aware of different elevations of the photo airplane betw. 9600 and 2400 ft.
Connors, Peter	"	No research originated out of Bodega Marine Lab on DO (email 3/17/01)
Currie, Larry	"	Forwarded Bert Johnsons article to me (email 2/14/01) and helped me with locating Johnson (email 2/15/01)
Del Tredici, Peter	"	Arnold Arboretum, Jamaica Plains, MA. According to Raiche, Del Tredici was interested in DO and DP.
Dumont, Gabrielle		Co-author with Shoonover of paper cited. She does not have a copy, Schoonover has graduated. I have not been able to locate Schoonover.
Dye, Chris		Verbal during visit to Yerba Buena Nursery on 3/3/01-referred to Dora Emory's book for summary of propagation. Lose plants when "prick ot" sprouts to plant in deep

		clay pot.
Ertter, Barbara	"	One of "Tibor's Dozen" (see below). Referred me to Nevling. Dr. Ertter is at UC and the Jepson Herbaria.
Greene, Katherine	"	Identified locations of DO at Rancho San Antonio Park (email 3/1/01) as well as contacted Ken Himes (email 2/ /01)
Heiple, Paul	"	Response of May 10 (?) to my email of 4/16 have been used as appropriate. Paul has lots of experience seeing DO and DP. However, he has 1) not exp'd contact dermatis 2) not seen rodent dispersal of seeds, 3) not aware of chem analyses, 4) points out that yellow is a color used by plants that have nocturnal pollinators, 5) that airborne pollination seems like a low probability, 6) suggests looking into the Western flower thrip as a possible pollinator 7) sees DO at plant sales (4 at CNPS this year), 8) supports the "disturbance" hypothesis as helping DO, 9) believes Los Trancos and Hamm's Gulch populations are the biggest local ones, 10) notes N and NE facing slopes, gravely soils, and the need for late season moisture, and 11) has observed the Los Trancos population re-growing from roots including as a means of propagation.
Holl, Justin	"	Suggested contacting Stermer, Schilling, and possible study directions (verbal late Jan, early Feb 2001)
Himes, Ken	"	Ken hypothesized that DO has out-lived it natural pollinator.(phone con. 2/ /01) Also pointed me toward June Bilisoley
Johnson, Bert	"	Reviewed his experience w/trying to propagate DO for EBBG (phone con 3/4/01)
Lake, Diane	"	Letter 4/24/01 on DO locations in the E Bay. Also email of 5/12/01 sites locations I've used in the report.
Mangels, Stephanie	"	First to mention Paul Heiple (email 2/12/01)
Mudd, Tom		None of the 11 species of species of bats at JRBP are nectar eaters (verbal 4/19/01)
Nevling, Loring	"	Leaving on trip to China-back mid-May (email 4/12/01). He has several refs that he will get to me when he returns. For DP, he doubts airborne pollination; there is only one genus, a South African, in the family that is wind pollinated; also doubts runners. Thinks insects are the pollinators. Thinks birds must be the seed dispersers because the species would have had a tough time getting spread as widely after glaciation (10,000 years). Has a ref he'll get me on impact of fog on DO. Believes the plants reach 50+ years. DP plants are lankier w/more shade. Nevling also wondered if DP can recover from fire.
Nesom, Guy	"	No additional work on DM. Referred me to Anderson (DM) and Nevling (DP) (email 4/25/01) In email (4/11) said what he wrote in '95 is about what he knows.
O'Brien, Bart	"	Experience trying to propagate DO similar to others familiar with Yerba Buena approach.
Olsen, Brad	"	Found slides of DO fruit taken at Chabot Regional Park, Bird Trail, in June, 1994. Suggested checking out that location. (email 4/25/01) Also suggested contacting Lake (email 4/11/01) and Steve Edwards (EBRP) (email 4/10/01)

Preston, Katherine	"	Helped in locating Ackerly data (email 2/12/01).
Raiche, Roger	"	Provided history on EB Botanical Gardens activity (Tilden Botanical Garden). Cross-reference to Bert Johnson and Peter Del Tredici Actually grew DP at UC Botanical Garden for ~10 years. "Never did sucker the way ours does (unfortunately a gopher got it ~5 years ago)." Mentions Rhamnus crocea, Sambucus mexicanus, Corylus calif, Melica imperfecta, and Triteleia laxa, in addition to what is mentioned in this paper, as the most common associates.
Schilling, Jessie	"	Numerous emails beginning 2/8/01 plus trip together to Yerba Buena. Many leads on people. Plans to do experiment w/root propagation.
Schulz, Kurt	"	"We have been able to demonstrate"...the halo of seedlings around established individuals " ... statistically." "I had a grad student monitor bird activity around leatherwoods...She saw nothing in two week's observations" Fruits ripen and ..."drop quickly, almost en masse and that they disappear rapidly. The broken fruit coats and seed coats" ...suggests "heavy rodent perdition. Notably, very few seeds are eaten or taken before they are ripe. We do not see clusters of seedlings, which would indicate caching by rodents." "The species is very toxic I have heard from folks who tasted seeds/fruits, and they regretted it." (email 4/3/01) In another email (3/29/01), Kurt suggested the wide yearly variation in seed set argues against wind pollination; also the flower morphology doesn't help and the heavy understory works against it. His bet is hymenoptera.
Starmer, Kathleen	"	Helped in locating Ackerly data. Also described DO seeds when ripe Has not seen bird activity but has seen empty seed pods.(verbal 4/26/01) Also suggested using bridal veil material as bags for catching DO seed. (long email 2/27/01 reviewing her 3 years of work w/Ackerly)
Stromberg, Mark	"	Advised me there are no DO at Hastings Natural History Reservation (email 4/27/01) Hastings is located at Carmel Valley, CA
Tibor, David	"	Suggested a dozen possible personal contacts on DO (email 2/14/01)
Timby, Sara	"	Referred to Jill Otto at Falconer Library (email
Wendt, Tom	"	Gave me current locations of Nesom and Mayfield (email 4/2/01)
Wilber, Cindy	"	Several emails on search strategies, beginning 2/9/01. Also forwarded comments from docents, eg, one saw sparrow on DO eating buds
Williams, Chuck	"	Looking at DP this season:reproductive biology (pollination). Have done "floral manipulations, pollinator observations and identifications, fruit set. Have data on size/age structure, water dispersal of fruits, etc. Nothing yet is published...The study you seek was done by undergrad...but she did little with the data and

		write-up." (email 4/12/01)
Young, Rebecca	"	Unduplicatible help with GPS logging, data transfer, data plots, aerial photos, humidity/rain/fog data, etc, etc (2/01-5/01)
Young, Robt	"	Identified DO locations on the Peninsula (emails 3/1, 2/16
Zasada, John	"	In addition to authoring DP survey article, referred me to Kurt Schultz and Bill Matson (email 3/23/01) Also sending Ramsewak paper on phenolic glycosides and DO. In another email (3/27/01) he mentions that he has been monitoring DP for about 6 years in the Ottawa National Forest: 10 or so shrubs each in 5 sites in Upper Peninsula of MI (Schultz offered to meet me there in May, 2001, but I couldn't make that trip.)

C

May-01
Rev August 01

Appendix II
Dirca Network

Name	Phone	email/web site	Comments
Ackerly, David	650-723-0176	dackerly@stanford.edu	Stanford U professor. Studied DO as part of burn project.
Anderson, Gregory		Ander@uconnvm.uconn.edu	Accompanied Nesom and Mayfield on 95 trip to Mexico. Maintains interest in DP but no research yet.
Bilisoley, June		jbili@aol.com	Protected DO on Los Trancos Rd from developer.
Brown, D. G.		DGBrown@CSBSJU.EDU	St Benedictine College, St Jude University (MN) Research interest in DP (pollination and seed dispersal). Also has colleague he's trying to interest in doing phyto-chemistry work)
Brown, Irene		ibcon@batnet.com	JRBP docent class lecturer (ecosystems). Saw misc ants on Dirca. Saw machete work at jct of 10 and 12. Also gave me Microbial Ecology ref (see pers comm in Appen I)
Buckout, Stephen	408-296-3587	yscottie@pacbell.net	Nominal author article on DO in 9512 edition of Edgewater News Stephen told me he didn't write it; thought Ken Himes had.
Ca. Native Plant Society		www.cnps.org	
Cal Photos		www.calflora.org	12 photos of DO.
Corelli, Toni	650-726-0689 (h)	corelli@coastside.net	JRBP docent class lecturer (wild flowers). Member CNPS
Curry, L		lcurrie@calacademy.org	Research librarian at Calif Acad. Of Science Located article by Bert Johnson
Deutsch, Ray		rdeutsch@stanford.edu	CNPS "propagation" chairperson for SM CNPS but not experienced w/DO
Falconer Library (Stanford Bio)		www-sul.stanford.edu/depts/falconer/index.html	
Gardner, Ken, Photo Gallery		www.stanford.edu/rawlings/kengif/dirca.htm	

Graves, William R.	515-294-0034	graves@iastate.edu www.hort.iastate.edu/pages/faculty/g_frame.html	Visit to DM in Mexico possible in spring, 2002
Greene, Katherine		kdgreene@etrade.com	Gave me DO locations at Rancho San Antonio Park
Heiple, Paul	650-854-7125 (h)	LogH3O@aol.com	CNPS. Led DO tour for SCValley CNPS in Feb 01. Lots of field experience.
Himes, Ken	650-591-7124 (h)	none	CNPS. Gave me DO Los Trancos Rd and other locations. Also Bilisoley contact. Mentioned Johnson's efforts. Also gave me Axelrod reference.
Holl, Justin	650-851-0619 (o)	justinh@stanford.edu	Authored a 1995 study of DO as a JRBP docent candidate. Now Asst Prog Coordinator for the docent program. Did some GPS logging post-95. Showed me how to use GPS.
Hubbart, Lori		lorih@mcn.lori	Could not locate. One of Yerba Buena associations.
Isenberg, Gerda			Founder of Yerba Buena Nursery. Retired 1995 at 94. Deceased. see www.stanford.edu/~rawlings/yerba.htm for history
Jepson Herbaria			
Johnson, Bert	510-841-8732 Need to leave a message.	none	Horticulturist at EBRP Botanical Gardens. Hard to reach. Has successfully propagated DO seeds by cold stratification. See The Four Seasons, J.of the Regional Parks Botanic Garden, 12/94. "Plight of the Western Leatherwood", which Johnson authored.
Korbholz, Bill		bill@korby.com info@friendsofedgewood.org	Pres, Friends of Edgewood, helped with referral (eg, Buckout)
Kremens, Clair			Has done pollinator studies. Caught pollinators with net. Noted subtleties of watching pollinators, like sometimes males are just chasing females while while females are doing the work (I knew that!). She is moving to Ivy League school position. No on-going interest apparent in Dirca
Lacy, Louise		ladylfab@earthlink.net	Gave me reference to Johnson.
Lake, Dianne		diannelake@yahoo.com	Sent me letter w/locations of DO in Alameda and Contra Costa Counties--some of great historical age.
Lowery, Judith Larner		myrealbox.com www.larnerseeds.com	Collected DO seed w/Gerda Isenberg 25 yrs ago on skyline. Weren't able to get it to germinate.
Mattson, W.G.		wmattson@fs.fed.us	Co-author w/Zasada et al on "novel glycosides"--see biblio.
Mangels, Stephanie		stephmangels@hotmail.com	Docent at Edgewood. Referred me to Heiple, Struthers, Deutsch.

Martens, Tim and Gwen		timandgwen@sympatico.ca	A Sense of Place Natives (DP). Has tried to grow DP w/limited success.
Mason, Judy			Docent, artist, and co-teacher of the wildflower class at JRBP.
Mostly Native Nursery	707-878-2009		Walter (propagator): no experience w/DO
Nesom, Guy		guynesom@intrex.net	Discovered DM. No follow-on research. Identified Anderson as an associate on 1995 trip. Also recommended Nevling, whom he'd heard had borrowed DM material for possible molecular-phylectic assessment. Nevling has done a lot of work of the family (Thymelaeaceae).
Nevling, Lorin I.	217-762-8070 1191 Sandra Lane Monticello, IL 61856	lnevling@monticello.net	Illinois Natural History Survey. Has done Dirca research. Back from China in in mid-May. Wrote paper (see App I.). Has a text for "St. Louis" but but nothing published "as there are at least 2 major problems to be resolved for DP (not clarified). Believes DP must be spread by birds "otherwise it would have found it difficult to re-establish itself into Canada following the last glaciation. S. Illinois to lower Canada is a big jump in just 10000 years." "The fruits are likely poisonous as the fruits of almost all Thymelaeaceae are...the compounds are coumarin-related." "DO distribution is controlled...by the fog streams. There is a paper on this I think...I'll get the reference when I get back." "Pollinators are probably insects based on the general floral gestalt...There is a single genus in the family that seems to be wind pollinated--it is S. African." "I don't think D. sends out runners, but I do wonder about fire resprouting." "There is a good paper on propagation of DP out of Arnold Arboretum. I'll look for it when I get back."
O'Brien, Bart. C.		bart.obrien@cgu.edu	Director of Horticulture, Rancho Santa Ana Botanic Garden, Claremont, Ca Worked at Yerba Buena.. Propagated D.O. from seed. Cold stratification. Referred to Timby. Gave me locations he knows.

Olsen, Brad		bolsen@ebparks.org	EB Regional Parks. Knows East Bay locations. Suggested contacting Steve Edwards at EBRP Botanical Garden whom I never reached.. Also mentioned Bird Trail at Chabot Regional Park; has slide of DO there from 1994.
Otto, Jill	650-725-1276		Research librarian at Falconer Library.
Preston, Katherine		kap1@Stanford.EDU	Helped in locating Ackerly data.
Raiche, Roger	510-849-4485	gardens@planethorticulture.com	U of California Botanical Garden (supervised native plant collection for 21 years. Now owns Planet Horticulture, since 1997, w/ David McCrory.
Saratoga Hort. Foundation	408-779-3303 (San Martin)		Sue says "no experience w/Dirca"
Schilling, Jessie	650-851-5162 (h)	grew@pacbell.net	JRBP docent (inactive). Highly knowledgeble about Ca native plants. Suggested Kathy Crane, Chris Dye, Jean Struthers, Bart O'Brien, Bert Wilson, Erin O'Dougherty, Roger Raiche. May be able to do root propagation study. A WONDERFUL SUPPORTER in this project.
Schultz, Kurt		docecology@aol.com kschultz@siue.edu	U of S. Illinois. Works on D.P ecology with grad students. Also works w/Zasada in MI (see below) Publications in preparation. Abstracts will be sent.
Sims, Cathy			Redwood City Nursery.
Smith, Gary		gksmith@pacbell.net	JRBP docent. Teaches GPS class. Did GPS logging of DO.
Sunset Reader Services	650-321-3600		no call back
Starmer, Kathleen		kathleen@starmer.com	Bagged ceonothus seeds using bridal veil material. Also very knowledgeable as participant in Ackerly's work. Also instructor in use of plant water measurements w/"bomb" pressure chamber.
Stromberg, Mark		stromber@socrates.berkeley.edu	Director of Hastings Natural History Reservation. No DO there.
Struthers, Jean		jeanstruthers@aol.com	Interested in trying to propagate seed. Suggested contacting Cathy Sims at Redwood City Nursery or Lori Hubbart. Both worked at Yerba Buena in the past.

Tibor, David P.	dtibor@cnps.org	Rare Plant Biologist, CNPS (Sacramento). Not much in his files on DO. Gave me 11 other possible sources.
Tilden Park	friends@nativeplants.org	emailed but could not find anyone knowledgeable on DO
Timby, Sara	stimby@sulmail.stanford.edu	Librarian at Stanford who is a CNPS member/officer. Referred me to Otto and gave me web site for Falconer Library.
UC Berkeley Bot. Garden		
UC Santa Cruz Arboretum 408-427-2998		

Wilber, Cindy	650-327-2277 (o)	cwilber@stanford.edu	Program Coordinator for the JRBP docent program. Helped point me in the right direction on Internet search with www.google.com/search?q=dirca+occidentalis+leatherwood&hl =en&safe=off&start=20&sa=N
Williams, Chuck	814-393-1936	cwilliams@MAIL.CLARION.EDU	Assoc prof of Biology, Clarion University of Penn. "Looking at reproductive biology (pollination) in a small population on the Allegheny High Plateau. We've done floral manipulations, pollinator observations and IDs , fruit set, etc. We also have data on size/age structure, water dispersal of fruits, etc. Nothing yet published" I was trying to find a paper by an undergrad of his, Stumpf, J. "Reproductive ecology of the riparian shrub DP..." 1999. Prof Williams said "she really did little with the data and write-up"
Wilson, Bert		netscape@laspilitas.com	LasPilitas Nursery in San Luis Obispo (would like seed)
Yerba Buena Nursery	650-851-1668	www.yerbabuena nursery.com	Kathy Crane is owner. Chris Dye is plant propagator; limited DO success. Founded by Gerda Isenberg. Has several resident DO.
Young, Rebecca	650-851-8715 (o)	rebecca.young@stanford.edu	JRBP GPS expert. Prepared Fig. 1. Did GPS logging. General source of any data one needs at JRBP, eg, weather, digitized aerial photos, GPS, and how to navigate the JRBP website. (WOW!) And ALWAYS READY TO HELP!!!
Young, Robert		bndyoung@juno.com	Gave me location of D.O. in Edgewood Park. Also cites San Carlos/Belmont Sierra Club has a trail going by them. Also Pulgas Ridge trail entrance has DO specimens he thinks are bigger than at Yerba Buena Nursery.
Zabel, Carol		none	Botany specialist in the JRBP docent program. Did GPS logging on DO.
Zasada, John	218-326-7109	jzasada@fs.fed.us	Authored major review article on D.P. (see biliography) Now located in MN but monitoring DP in Upper Peninsula of MI Most of his DP work was done when located in WI Also authored article on novel phenol glycosides in DP.

Appendix III

Comparison of D. occidentalis (Western Leatherwood), D palustris (Eastern Leatherwood) and D. mexicana

There is more detail provided in the source documents cited. There probably are related species in Continental Europe and Asia

Trait	DO (1, 4, 5)	DP (2)	DM (3)
Location	6 Counties in N Central Coastal California-Med Climate Santa Clara, San Mateo, Marin, Alameda, Contra Costa, Sonoma	N Bruswick/Ontario on the N to Florida and Louisiana on the S.	Sierra of NE Mexico (Tamaulipas) 2500 km from nearest DO 1100 km from nearest DP
Biogeography	Separated from eastern species by possible glacial action across Central US, emergence of Med. climate in West	Species spread across N. Am.through much of Tertiary, beginning as early as Eocene.	Disjunct from SE US established in mid-to late Miocene.
Abundance	Rare-!B rating, CNPS Jasper Ridge population observable from 20+ trails and fireroads on 1200 acres is 900-2200. Additional D.O. at Jasper Ridge is highly likely. CNPS also has another rating code called R-E-D. DO is Rarity=2 (distribution is a limited number of occurrences); Endangerment=2 (endangered in a portion of it range); and Distribution=3 (endemic to California). So R-E-D=2-2-3.	Wide-spread population but restricted	One location: Arroyo Obscuro on 35km rd. from Sta. Engracia to Dulces Nombres. 800-1000 plants over 300 m in open canopy microsites, singly and clusters Could not identify features which account for rarity.
Other names	Western Leatherwood	Eastern Leatherwood moosewood, rope-bark, wicopy Atlantic Leatherwood American Mezeron (European name)	Mexican Leatherwood?
Description	Ht 2-3 m; basal dia. 1-5 cm although Yerba Buena specimen closer to 10 cm.; crown dia more like 1m. Frequent branching and apical growing points.	Ht 3-4m; basal dia. 5-10 cm; crown width and depth 2-3 m; largest crown vol. 15-25 m3. Frequent branching and apical growing points.	.6-2 m., ave 1.6m; 2-3cm stem.

Trait	DO (1, 4, 5)	DP (2)	DM (3)
	Roots not examined.	Root depth of larger plants 2-3m	Roots not examined.
	Deciduous	Deciduous	Deciduous.
Habitat	Does best on N or NE facing slopes. Likes moisture but generally not seen in standing water (except Trail 12/marsh).	Mesic, relatively rich hardwood forests or mixed conifer hw forests. In aspen ecosystems in upper Great Lakes. In a given site, can be random to aggregated.	Found on steeply sloping, north-facing, mesic cove surrounding a rocky watercourse. Area lime-stone w/karstic tendencies. Ca. 1800m. Evidence of logging.
	Associates with species that provide low or semi-open canopy, eg, buckeye, deciduous oaks, smaller bays, and other shrubs, including holly-leaved cherry, toyon, and other chaparral. Will become spindly if overstory becomes dense, eg, mature bay or oaks.	Dense overstory. Removal of canopy seems to reduce growth. Not sure this is due to light or damage incurred when harvesting trees. Will form callus relatively quickly.	Canopy deciduous w/Carya ovata, Pinus patula, Pseudotsuga menziesii, Quercus laurina. These reach 20-25m, w/30m poss.
	Understory mixture of ferns, hillside gooseberry (Ribes), poison oak (Toxicododecron), osoberry, toyon, coffee berry,	Often the only understory shrub. With woody trees tolerant to understory, like, sugar maple, ironwood, white ash, eastern hemlock, balsam fir.	Evergreen understory, ferns major part. Herbs include Chimaphila, Chiropetalum, Goodyera, Sisyrinchium, and Stachys. Arboreal bromeliads, including 3 species of Tillandsia, are conspicuous.
		N Carolina lists D.P. as a shrub suitable for swampy landscaping and advises against use over a septic tank.	
Pollinators	Have seen 4 honeybees on 3 plants TOTAL. Have seen ants on one plant on Trail 8 on two occasions. Have seen ants in quantity going from point A to B on a horizontal segment of a downed shrub.--no	?	Saw one species of bee and 4 species of butterflies nectaring. Examined numerous flowers but did NOT see nectar.

Trait	DO (1, 4, 5)	DP (2)	DM (3)
	evident interest in flowers. Have seen one hummingbird to "fly-by": hover and move on. Could be airborne pollination or a night-time pollinator. In my field notes I observed, "This flower is saving itself for true love. It doesn't "want" any of these insects.		
Flowers/ Fruits	The flowers have an everted stamen and anthers. A pollinator "sees" a rather closed access to the nectary. The flowers do not seem to respond to more or less light to open or close.		Initially, apical stigma is elongated past anthers and appears moist. Appear to have pollen attached. At full athesis, open anthers are to the level of the stigma or slightly beyond. Little time betw. initial receptivity of stigma and dehiscence of the anthers.
	Superior ovary, 8 stamens.	Superior ovary, 8 stamens	Superior ovary, 8 stamens.
	Monoecious. Described as bi-sexual.	Monoecious.	Appear weakly protogynous "and there is evidence may be self-compatible".
	DM similar to DO in bud scales,. with whitish pubescence, sessile flowers and fruits, distinctly lobed calyces, and persistent pubescence on the young twigs and axial leaf surfaces.	DM similar to DP with long calyx and abruptly flaring limb.	Prepared "key" which shows species differences. These are in bud scale color, leaf surfaces, flower/fruit attachment, calyx shape and length, insertion of stamen filaments, degree anthers exserted, location of style and stigma at maturity v. anthers. Flowers are longer with a narrower tube than DO. Shorter limb and lobes and shorter style and filaments.
	Pale yellow flowers. Clusters of	Pale yellow, fragrant flowers.	Pale yellow ?, no fragrance.

Trait	DO (1, 4, 5)	DP (2)	DM (3)
	2-3 most likely.	In clusters of 2-7. Small conical buds. 2-3 most likely.	Invariable 3 flowers in axillary fascicles. Apical fascicles sometimes "twinned" (6 flowers)
	No nectar production?		No nectar production?
	Most "mature" plant I've seen is at Yerba Buena Nursery on Skyline. Did not count flowers. DP numbers seem HIGH. In general, DO may be smaller than DP, which may explain.	4 distinct dark, silky scales that persist after flowering. Mature plants produce 300-1500 flowers w/greatest number observed about 4500 (!).	?
	Early blooming. Dec-Mar. Flowers ahead of leaves.	Early blooming (April) before the overstory, leafs out into May.	Early March, 1995. Highly synchronous blooming. Flowers ahead/concurrent w/leaves.
	Ahead of canopy.		Ahead of canopy.
	Fruits ripen May?-June	Fruits ripen June-July to as late as S-Oct. WI-MI study: 75% of seeds contained embryos that filled 80%+ of seed; when fully ripe endosperm is a minor component of seed. Not easily sep. from seed coat until mid-late June.	Not observed after flowering
	Immature fruits are green.	Immature fruits are green. Change to light green. Almost white when fall. Fleshy outer fruit wall turns black w/in 24 hrs in some, remains light gr for several days in others.	Immature fruits are green. Did not obs. mature fruit.
	One seed/flower. Drupe.	Generally, 1 fruit/flower. Fruits 1-3/cluster most common. Fruit is a drupe.	One seed/flower. Drupe.
	No one I've found knows dispersal vector.	Dispersal over 2 week period. Individual plant 2-3 days to 6-8 days. Birds not critical in seed removal, but they do use some seeds.	
	Inside seed flesh, the fruit is dark brown-black	Rodent impact? Remnants of the black seed coat failry common under plants 1 mo after dispersal.	

Trait	DO (1, 4, 5)	DP (2)	DM (3)
		Once fruits fall naturally, fruits have fully-developed seeds. Based on cutting tests, 90-100% of developed fruits contained seeds w/ apparently viable embryos.	
Germination	Successful horticulturalists have used 2-3 month cold stratification. Kept in plastic bags in moist vermiculite, monitored for germination. Transferred to flats. Low success overall.	Untreated seeds in a nursery bed soon after collection produced seedlings (67%). Other sources specify the need for cold stratification	
Microbial	Mycorrhizal association?	?	?
Seedlings	Slow growth	Grow to 20-30 cm in 5-10 years in nature.	Slow growth likely
Regeneration	Trail 9 is maintained by cutting DO to ground level. Resprouting evident. Layering not evident. Seedling regen. seems most likely, but may respond to stress by sprouting from roots/crown. No literature on fire-tolerance.	Poor sprouting if main stem broken/cut Layering does not occur even when in good contact with soil. Seedling regen. most common.	No roots unearthed, but NO evidence of reproduction clonally. Discounts 1935 report of rhizome production. (reference (4) below). Authors refer to Sponberg (pers. comm) ?
Herbivory	No browsing by deer on flowers or leaves evident. Insect damage rarely (as of May 01). No diseases evident.	Little browsed by deer.	?
Toxicity	?	Diuretic qualities; stem contains large quantities of calcium oxalate crystals, a salt of oxalic acid. Oxalic acid is a colorless organic acid found in many plants. "Novel" phenol glycosides. Phenol is a caustic, poisonous white crystalline compound, C6H5OH derived from benzene and used in resins.	?
	Flexing of stems does not seem to	Listed as poisonous in multiple sources. Contact	

Trait	DO (1, 4, 5)	DP (2)	DM (3)
	cause contact dermititis nor does. touching of leaves.	dermatitis reported; stomach aches and death have been reported from seeds.	
Max age	?	30-50 yrs?	?
Annual Growth	Similar to DP. Ackerly has data.	1-25 cm/meristem 0.5-1 m cumulative	?
Sp Gravity	I sectioned two specimens that had been accidentally "machete'd" by birders seeking access to the marsh at the junction of Trails 10 and 12. The material was well weathered. The specimens were both about 1 1/2 m tall; one trunk 3 cm in dia, one about 4 at the widest point (not concentric in cross-section). The trunk was light, like balsa wood, but not cohesive; easily shreaded on free end. I counted approx. 20 'growth' rings for each shrub. The absence of cohesion between layers makes growth ring counting a little dicey. Could easily have been several years since cutting, so these had lost flexibility. See reference (4) below.	.41-one of least dense plants, due to low level of lignification. Flexible.	?
Other	Ohlone used flexible branches, bark. Extracts from leaves and stems have been identified as anti-cancer agents. (See note (5)).	Ojibwa made bowstrings, baskets, and fishing lines.	?

Notes:

1. DO observations are based largely on my observations at JRBP, Justin Holl's Docent Project (1995), and Friends of Edgwood Newsletter 1992 (9512) (Stephen Buckout, listed as author, says he was not). I could not find anyone claiming to be author, although S.B. thought it was Ken Himes (see Network)

2. DP observations are based on "Dirca palustris L.", published in <u>The Woody Seed Manual (under revision)</u> by John Zasada, David Buckley, Elizabeth Nauertz, and Colleen Matula, (I am in contact w/ Zasada)

Trait DO (1, 4, 5) DP (2) DM (3)

(respectively, research silviculturist, ecologist, and biological technician at USDA Forest Services North Central Research Station, Grand Rapids, Minnesota; botanist at USDA Forest Services Ottawa National Forest, Bessember Ranger District, Bessemer, Michigan). Article available on Internet.

3. DM observations are based on SIDA Contributions to Botany 1995 v16, #3, p459-467. Authors Nesom, Guy L; Mayfield, Mark H, University of Texas, Austin, TX 78713 USA. "A new species of Dirca from the Sierra of ne Mexico".

4. See photomicrographs in "Notes on Western Leatherwood, Dirca Occidentalis Gray", Madrono, Vol 3, p.119. 1935. This explains flexibility and specific gravity.

5. Anticander Research, 1995. v 15, #2, p.233-239. Suh, Hanjoo. Refers to genkwanin, lariciresinol, and sitoindoside evaluated in an HL-60 cell differentiation model.

Also found 1983 reference. J Pharm Sci, Dept Pharmacognosy and Parmacol., Coll. Parmacy, Univ. Ill. Med. Cent Chicago Ill. Plant anticancer agents: 27. Antileukemic and cytotoxic constituents of DO. V 72, No. 11, p 1285-1287.

I have only looked at the abstracts of these papers. The source material is in Lane Medical Library. There probably is more detail on the chemistry of DO in these papers. A drug company would make a synthetic analogue of this and would probably seek to eliminate as much of the potential toxicity as possible. Chemotherapeutic drugs are administered IV, usually, so contact dermatitis could be a problem commercially.

Dirca Occidentalis in Jasper Ridge Biological Preserve

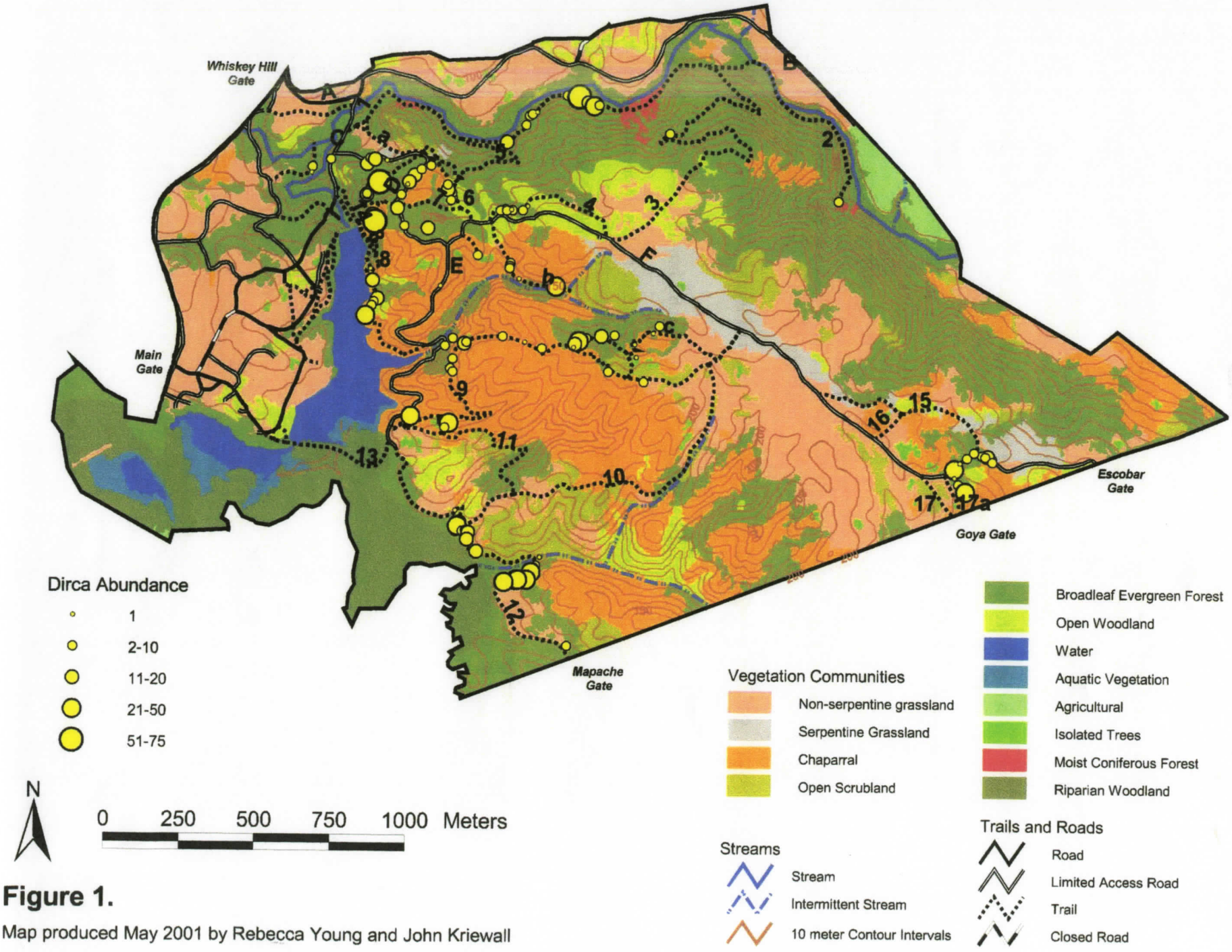

Figure 1.

Map produced May 2001 by Rebecca Young and John Kriewall