

CONSERVATION THROUGH DATA MANAGEMENT AND TAXONOMIC  
DELIMITATION

by

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(Under the Direction of James Leebens-Mack)

ABSTRACT

Conservationists are the primary defense for the planet's natural resources. Animals are generally mobile and well-protected through federal and state laws. Plants, because of their non-motile life form and private property laws in the United States are generally more difficult to protect. Shoestring budgets, limited manpower, and taxonomic uncertainty further exacerbate plant protection. This dissertation aims to provide support to those in the field of plant conservation by providing insights on approaches to data management and taxonomic delimitation.

INDEX WORDS: Conservation, *Cercis canadensis*, *Cercis*, taxonomy, morphometrics, quantitative traits, phenotype, genomics, pluralistic, species concepts

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## DEDICATION

This dissertation is dedicated to my wife, Kristin Frew McNair; our son, Miles Carter McNair; and my mother Karin McNair.

Kristin, your relentless support throughout my PhD (whether I wanted it or not) is the main reason I was able to achieve such a feat. I truly am unable to express how much you helped me through this process and I will be forever grateful. Also, you were right... as always.

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## CHAPTER 1

### INTRODUCTION

The goal of this dissertation is to inform plant conservation practices and the development of a practical framework for taxonomic delimitation. Originally focused on the genus *Sarracenia* (Sarraceniaceae), which has known taxonomic and conservation issues, an unexpected data breach led to switching to a genus with no conservation concerns, *Cercis* (Fabaceae), and the development of a new chapter on the best practices for handling and managing sensitive conservation data. The first content chapter of this dissertation is a qualitative study intended to inform best practices and training in the maintenance of data security and trust among conservation resource stakeholders as elucidated through semi-structured interviews and thematic analysis. The second and third chapters use *Cercis* as a model system to explore and develop traditional and modern approaches to taxonomic delimitation. The final chapter discusses approaches for expanding this line of research in the future.

Given the technological advances in high throughput sequencing and phenotyping, the future of taxonomy includes integration of genomic and phenotypic data. Utilizing an integrated approach for genomic and phenotypic data analyses, together with well-justified and clearly articulated species concepts allowed the development of a rigorous and reproducible methodology for species delimitation. Utilizing North American *Cercis* as a model and a pluralistic approach to taxon delimitation (Figure 1.1), I developed and applied a data-driven framework for conceptualizing species, subspecies, varieties, and forms.



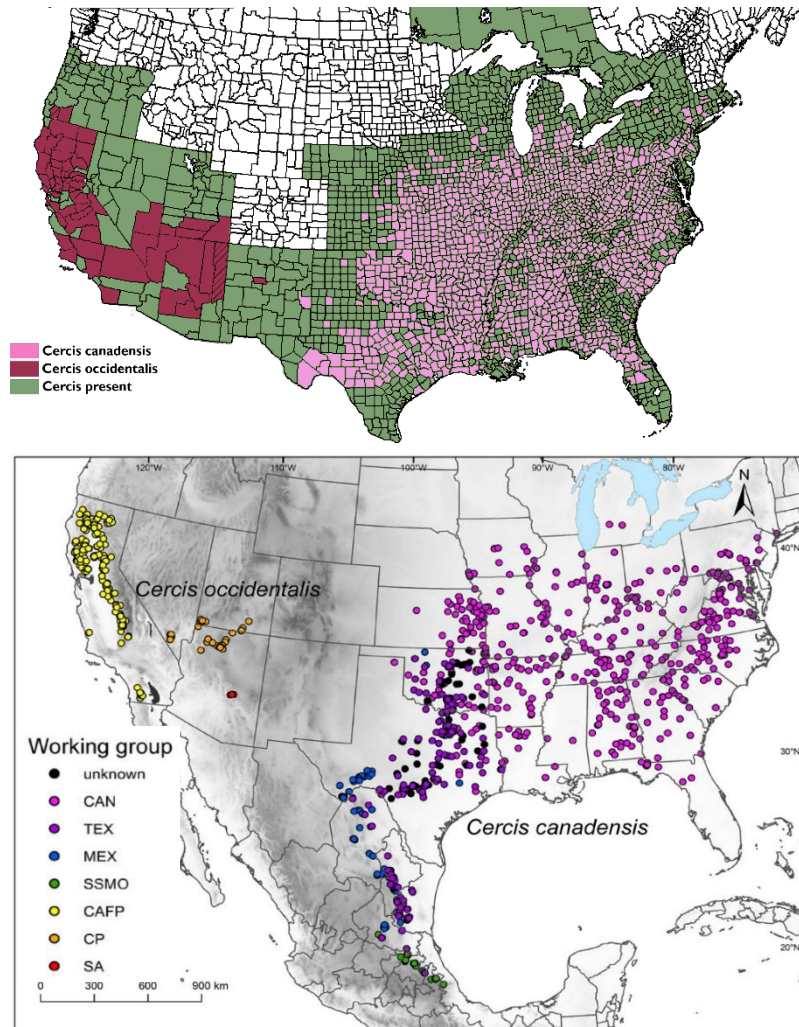
## Taxonomy

The genus *Cercis*, like many genera, is fraught with taxonomic controversy over species and subspecies designations. Circumscriptions of species, subspecies, varieties, and forms of North American taxa are hotly debated in the taxonomic and horticultural literature. Linnaeus describes *Cercis canadensis* as having “*foliis pubescentibus*” or pubescent leaves. As remarked by nearly every botanist that has published a taxonomic revision of North American *Cercis*, the dominant phenotype of this species throughout its range (Figure 1.2) is nearly entirely of glabrous foliage, rarely with sparse hairs in the axils of the leaf veins but only on the underside of the leaf blade (abaxial) (Greene, Hopkins, Murray, Fritsch, etc.). Subsequent taxonomic descriptions have attempted to delineate using the broad range of habitats, vegetative, flora, and fruit phenotypes found across *Cercis canadensis*’ natural range. The most important traits historically recognized are leaf pubescence, thickness, glossiness, and shape (base & apex); fruit size and pubescence; flower size and color; and overall plant habit (shrub or tree). The consensus among those working with North American *Cercis* is that there are at least 5 distinct taxa within the group (Fritsch et al. 2018) (Table 1.1). The most recent taxonomic treatment recognizes two species and three varieties. In addition, a cryptic species segregating within *C. occidentalis* has been hypothesized (Fritsch et al., 2018; Hopkins, 1942). Fritsch and coauthors performed a comprehensive morphological analysis of leaf and flower traits together with internal transcribed spacer (ITS) and chloroplast gene-based phylogenetic analyses. They identified a distinct population within *C. occidentalis* and asserted it should be recognized as a species bearing the name *C. orbiculata* Greene. At the same time, Fritsch

et al. (2018) lump populations with narrowly overlapping or distinct morphometric traits into *C. canadensis*, recognizing them as varieties within *C. canadensis* but not species.

**Table 1.1** List of North American *Cercis* taxa as described in Fritsch et al. (2018)

<b>Taxon</b>	<b>Locality</b>	<b>Working Group (Figure 2)</b>
<i>Cercis canadensis</i> var. <i>canadensis</i>	Eastern US	CAN (▼)+SSMO (X)
<i>Cercis canadensis</i> var. <i>mexicana</i>	West of the Pecos River in Texas	MEX (□)
<i>Cercis canadensis</i> var. <i>texensis</i>	East of the Pecos River in Texas	TEX (+)
<i>Cercis occidentalis</i>	Western US	CAFP (◇)
cf. <i>Cercis orbiculata</i>	Western US	CP (△)+SA (○)



**Figure 1.2.** Distribution maps adapted from BONAP data (A) and Fritsch et al., 2018 (B). Locations of the North American *Cercis* specimen collections used in Fritsch study. The seven working groups are denoted by color. CAFP, California Floristic Province; CP, Colorado Plateau; MEX, *C. canadensis* var. *mexicana*; TEX, *C. canadensis* var. *texensis*; SSMO, southern Sierra Madre Oriental; CAN, *C. canadensis* var. *canadensis*; SA, Sierra Ancha. Flowering specimens not assignable to a group were scored as unknown.

## **Species Concepts**

Having clear species definitions is necessary for effective conservation. While many species concepts exist, the term “species” can be defined in two ways: as a group of organisms with phenotypic characteristics that set them apart from others or as a term describing biological relatedness of members of a group (Levin, 1979). While a species concept defines taxonomic rank, there are a plethora of species concepts and variation in how taxonomists implement them (Figure 1.1). Circumscriptions of subspecific taxonomic rank are even more varied with taxonomist developing taxon descriptions based on their own judgement as to what constitutes a given rank. There have been dozens of species concepts developed to account for novel understanding of how speciation occurs (Cronquist, 1978; De Candolle, 1883; De Queiroz, 2007; Mayr, 1943; Sneath, 2007; Van Valen, 1976; Figure 1.1).

When developed, few of these species concepts were intended for operational use in determining protections by regulatory government agencies. Legislation such as the Endangered Species Act require clear rules with which to distinguish organisms from one another and do not necessarily take evolutionary processes into account when defining species boundaries. Such an operational approach may or may not be useful for scientific understanding. The rules of governmental approaches to conservation do not necessarily conform with the scientific species concepts or with the potential complexity of species boundaries. As understanding of the natural world evolves, it is becoming more evident that the definition of species is not binary with universally defined rules. More complex and customized species concepts may be necessary to accommodate the complexity of the

world's biota. However, it may be that as more rules are created to account for natural variation, the more limited in utility each species concept becomes.

As the name implies, a Pluralistic Species Concept (PSC) can encompass all other species concepts by allowing taxon specialists to define a species using the most biologically relevant criteria for that specific taxon, rather than applying one set of criteria for all organisms (Figure 2). At its core, the PSC acknowledges that any one species concept is not sufficient nor relevant to all taxa that may be able to be delineated based on one or more data types (measurements of ecologically functional traits, genotypic variation, morphology, etc.) and the definition of what constitutes a species should be based upon as many of these data types as possible (Cummings, Campbell, & Reece, 2002).

### **Approaches to Species Delimitation**

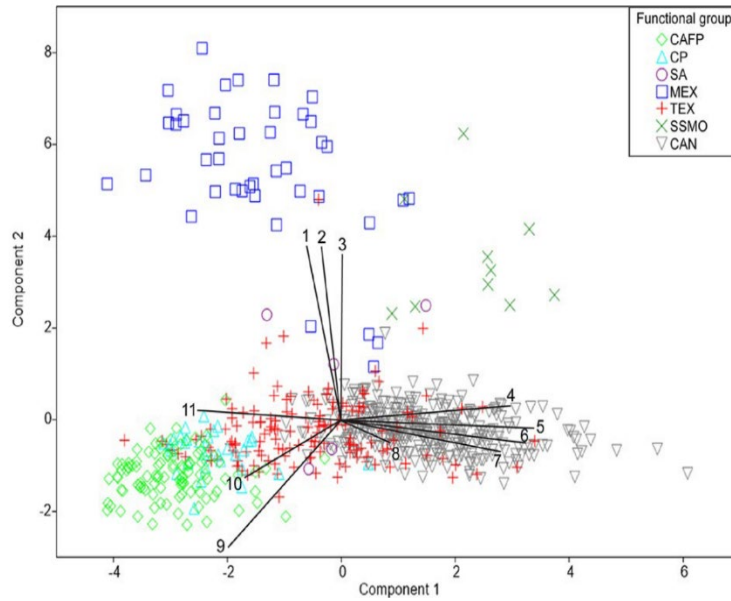
Historically, most taxonomic designations were based solely on morphological characters (Linnaeus, 1753; Michaux, 1803). Today, it is necessary to consider how and why phenotypic and genotypic variations came about relative to speciation. Phenotypic variation is often driven by external selection pressures such as predation, pollinator selection, climate, and more (Gilbert, Nitta, Talavera, & Pierce, 2018; Muchhala, Johnsen, & Smith, 2014). However, in some cases, selective pressures may influence genetics in ways that are incongruent with observed relationships based on phenotype alone (i.e. cryptic species) (Bateman et al., 2011; Bickford et al., n.d.; Carstens & Satler, 2013). More simply, genotypic and phenotypic divergence do not always align, posing a challenge for species delimitation. Differences in genotypic and phenotypic distinctiveness may be due to several factors, including the genes analyzed not being involved in development of the diagnostic phenotypic traits.

Morphometrics, taking measurements in natural settings of phenotypic traits both within and between populations, has been the cornerstone of species delimitation. However, the existence of cryptic species, phenotypic plasticity, and ongoing gene flow between named taxa can complicate species delimitation. With the advent of modern molecular genetics, we need no longer rely on morphometric analyses alone for taxonomic delimitation. Genetics and morphometrics have been shown to conflict in many cases thus muddling taxonomic designations based solely on morphology (Carstens & Satler, 2013; Hausmann & Huemer, 2011; Jang, Müllner, & Greimler, 2005). In contrast to morphometric approaches, genetic species circumscription using whole genome shotgun sequencing may offer an unbiased approach to identify distinct gene pools and delimit species. Modern taxonomic methods can now include both morphometric and genomic data analyses to best capture the evolutionary history of species (DeSalle et al., 2005). However, it is important to note that phenotypic data is not merely a surrogate for genotypic data and that phenotype is integral to the human ability to distinguish taxa as it provides observable differences for immediate distinction between taxa. **The primary goal of my dissertation research is to develop a foundational understanding of the relationship between genotypic and phenotypic variation in North American *Cercis* that will inform delimitation and inference of evolutionary history using both traditional morphometric and genomic approaches. That is, do genotypic and phenotypic data support the historic taxonomic delimitation of *Cercis canadensis*?** Specific objectives include:

**Objective 1 (Chapter 2):** Identify best practices for conservation data management through a qualitative study using semi-structured interviews, thematic analysis, and member checking.

**Objective 2 (Chapter 3):** Revisit Fritsch et al.'s (2018) morphometric work by measuring multiple accessions of their proposed taxa grown in a common garden setting and in an F2 breeding population (Table 3.1) to assess relationships between named taxa.

**Objective 3 (Chapter 4):** Leverage an F2 hybrid population derived from *Cercis canadensis* var. *canadensis* and *Cercis canadensis* var. *texensis*, and whole genome shotgun sequence data to perform a QTL analysis of the traits used to distinguish these taxa (Table 3.2).



**Figure 1.3.** Adapted from Fritsch et al., 2018. Principle component analysis of 11 morphological characters. PC1 and PC2 account for 37.4% and 25.5% of the total variation respectively. Black lines indicate component loadings for each character: 1, fruit pubescence; 2, branchlet pubescence; 3, leaf trichome density; 4, leaf apex shape; 5, leaf length; 6, leaf area; 7, leaf width; 8, fruit length; 9, fruit wing width; 10, fruit width; 11, leaf sinus shape. Functional groups coordinate with Table 1.1. This diagram generally conforms with geographic distribution of each working group when flipped on the Y axis.

## CHAPTER 2

### CONSERVATION DATA MANAGEMENT IN THE DIGITAL AGE

#### **Introduction**

In the early 21<sup>st</sup> Century, data security is an ongoing hot-button issue on a global scale. Technology giants like Google, Apple, Meta, Sony, and more have experienced data breaches in some capacity over the last few decades (Heiligenstein, 2022a, 2022b; Houser & Voss, 2018; Verizon, 2022). These companies dedicate massive budgets for technology development and personnel to maintain data security. However, the field of conservation often lacks the resources, standards, and workforce to properly maintain the security of the valuable data it safeguards. As a result, there is a severe lack of information on best practices involving the handling of sensitive information such as locality data for rare and threatened taxa (from here on referred to as data) (Michener, 2015; Popkin, 2019). There has been ongoing debate regarding sensitive zoological collections and population management data but not all the solutions proposed for animals are relevant or applicable to plants (Lindenmayer & Scheele, 2017; Lowe et al., 2017). This is likely exacerbated by disparity between public awareness and funding for conservation of natural plant and animal resources (Wandersee & Schussler, 1999). For example, the destruction of a group of charismatic megafauna (e.g., pandas, orangutans, pangolin, etc.) from the wild elicits a strong negative emotional response in the general public with prolific international news coverage whereas the destruction of an endangered plant species is usually much more subdued (Balas & Momsen, 2014; Donnelly, 2020; Gammon, 2019; Glaser, 2019; Sonner,

2020; Still, 2019). Tragic events like these may spark waves of monetary donations and public engagement with conservation agencies.

Regarding conservation data management, it is currently unknown how often data breaches occur and how often poaching events occur because of data breaches. Poaching is one of the biggest issues facing threatened taxa today (Lavorgna, 2014; Phelps & Webb, 2015; Smyth et al., 2017). Individual poaching events are unlikely to lead to the extinction of a species; however, the cumulative impacts of site visitation, multiple poaching events, and even permitted material removal contribute to the degradation of a species' survival (Participant 8 interview). Unfortunately, it is nearly impossible for anyone to link a particular data breach to a particular poaching event given the current pipelines in place. After a breach occurs it often takes weeks, if not months, to determine the full extent of what was leaked. By that time the damage has likely already been done. As these breaches can lead to extirpation of populations and damage to ecosystems, it is important the field begins to understand how these breaches occur and in what ways they can be prevented. The goal of this study is to identify best practices for conservation data management through a qualitative study using semi-structured interviews, thematic analysis, and member checking.

### **Workforce Issues for Conservation**

Conservation researchers and managers are often stretched for time and funding. In the face of increasing development pressures and climate change, investment in conservation workforce development is more important than ever. Outreach and public education are crucial for raising awareness about conservation issues including the need for increased public investment in conservation. At the same time, those working in

conservation are often wary of outsiders and with good reason; sharing data with the wrong person can and does lead to site impact at minimum and complete destruction in the worst cases (Oksanen & Kumpula, 2013; Welz, 2017). Best practices for conservation are rarely taught outside of on-the-job training or short-term academic workshops. University-level course syllabi for conservation-related degrees rarely if ever cover the handling of sensitive data and for many these best practices are learned through interactions with veterans of conservation.

The permitting process itself can be daunting for budding researchers as it greatly varies depending on which organization is granting the permit (Table 1). The permitting process is motivated by the need to have both researchers and resource managers understand the potential impacts the proposed research could have on the taxa and localities involved. Historically the permitting process assumes the permit holder knows how to best handle sensitive data and has done appropriate research into the system they are proposing to work with. Therefore, the responsibility for proper training lies on the permit requestor. The permitting process currently does not involve training the permit requestor in any capacity. Conservationists at Permitting Agencies and Data Repositories are often forced to either trust that the permit seeker is properly trained or rely on the limited bureaucratic infrastructure already in place to train and educate those that wish to become involved through the permitting process. As a result, newcomers to the world of conservation are often left wanting to become involved but lacking connections, knowledge, training, and opportunity, making them a weak link in data security.

## **Technology For Using Collections Data**

Use of digital technologies for handling geospatial data is another possible weak link. The hardware and software required for proper handling of data can be expensive and/or difficult to learn to use. The most secure hardware is handheld GPS; however, smartphones are more cost-effective and often do not require an additional purchase but are less secure. When considering hardware for use in-field, durability, cost, and security are the primary three concerns. Summaries of the current best options as described by interviewed stakeholders can be found in Table 2. The industry standard for software is ArcGIS by ESRI but requires a yearly subscription and substantial training to properly utilize. QGIS is a free alternative that is known for being unintuitive and difficult for inexperienced users to learn without hands-on instruction from an experienced user. In fact, some stakeholders interviewed for this study admitted having minimal to no knowledge of how to use either program, instead relying on collaborators to deal with the data directly. There are many online tutorials and in-person classes at conferences and universities offered on how to use these programs, but both are time-intensive and in the case of in-person trainings, potentially costly (Ridha & Kamil, 2021). These programs are considered secure, but these barriers can and do lead to stakeholders turning to more user-friendly alternatives that are much less secure (e.g., google maps; Table 3). In summary, the data is only as secure as the platform it is stored on, but less likely for a naïve poacher to be able to use more secure programs to access the data.

Smartphones provide quick, easy, and inexpensive solutions for hobbyists and professionals. Worldwide in 2021, there are approximately 3.2 billion people that own

smartphones with 77% of Americans owning them (Deyan G., 2019). Smartphones can be as inexpensive as \$30 or as expensive as \$1200 with relatively minimal difference in functionality between them for data management purposes. Simple phone cases provide durability, price point, cellular data, and built-in commercial grade GPS plus ease of app development makes smartphones the obvious choice for in-field data access. The problem with smartphones is insecurity. Most mobile phones come with built in map applications such as Google Maps (Android) and Apple Maps (iPhone) and there are many additional options for easy navigation (Waze & MapQuest). Google also provides the Google Earth and My Maps applications which allow customized map creation and easy manipulation of data. However, almost none of these options are considered secure for conservation data because of the privacy policies of the companies that manage them (Table 3).

Google Maps, My Maps, and Google Earth receive consistent updates and boast an easy-to-use interface including seamless integration between desktop and mobile applications including integration with Google Drive and Gmail. However, these frequent security updates with long, uninterpretable terms of service (ToS) explanations are a potential source of data insecurity. Very few end-users read these frequent ToS updates which may contain valuable information such as changes in default security settings on accounts (Obar & Oeldorf-Hirsch, 2018). As a result of these security updates, maps made within Google Earth, or My Maps may change from being completely private to link shareable or even fully searchable by the public depending on the update. Data breaches have occurred through applications such as My Maps and Google does not have any direct support line available to determine where the breaches may have occurred or why (Heiligenstein, 2022; Houser & Voss, 2018). Despite its ubiquity and ease of access we

recommend caution, vigilance and personal responsibility for data security when using Google products for the handling of conservation data. Community and citizen science platforms such as iNaturalist, iDigBio, GBIF, and herbarium consortia are generally viewed as more trusted with regards to safeguarding sensitive data but this has not been empirically studied or confirmed.

Navigation apps such as Google Maps (different from Google Earth or My Maps), Apple Maps, Waze, and MapQuest are perhaps slightly more secure in that you cannot directly upload shapefiles, but you can easily copy and paste GPS coordinates directly into them and most of the companies that manage these applications have had data breaches at some point in time (Verizon, 2021; Heiligenstein, 2022; Heiligenstein, 2022). All these apps require permission to access your location. As you use them, they continually record your location as well as any locations you search for within their app. This information is often available for purchase from these companies.

In this study I explore issues that may impact the security of plant collections and management data through qualitative assessment of transcripts from interviews with key stakeholders. This work is motivated by personal experience with a data breach. After an online map full of locality data was accidentally made public, the lead researcher lost the permits that provided access to crucial conservation data and therefore was forced to abandon the study. This breach caused great harm to conservation stakeholders, the exposed plant populations, and the researcher responsible for the data breach. To better understand how this and other data breaches, occur and how to prevent these situations from occurring, this study explored conservation data management policies and procedures with stakeholders that were directly and indirectly involved in the breach. It therefore is

specific to plant conservation in the southeastern United States but has potential to inform conservation practices more broadly.

### **Methods**

Research and knowledge regarding data privacy and transparency in conservation are limited. Additionally, there is a lack of consistent recommendations and best practices for the field. To address this gap, this study explored procedures, policies, and training surrounding data security within digital platforms used by conservation organizations. To that end, semi-structured interviews and a subsequent thematic analysis were conducted to elucidate the current best practices for handling sensitive data from three groups of conservation stakeholders: Permitting Agency Officials, Data Repository Managers, and Permit Holders.

### **Interview Sample**

Initial emails (n=30) were sent to conservation stakeholders from state and federal agencies, herbaria, and digital data repositories (iNaturalist, NatureServe, SERNEC). Those that replied (n=21) to the email agreed to participate in interviews to gather information on considerations for formulating digital conservation data management plans. Initial contacts were chosen because of the direct effect on their work by the lead authors' data breach and/or because they are a representative of an important or leading organization in the conservation community (SERNEC, iNaturalist).

### **Data Collection and Analysis**

The primary source of data included semi-structured interviews (n=21) with a wide range of stakeholders classified as Permit Providers, Permit Holders, and/or Data Repositories (Louise Barriball & While, 1994). Data from literature review provided

supporting data in rare cases; however, the topic of data security as it relates to conservation is a relatively new topic in peer-reviewed research and in the opinion of the author, understudied. Semi-structured interviews allow the interviewer to guide participants to explore relevant ideas that may seem tangential to the main topic allowing for a deeper exploration of the participants' experiences, beliefs, and thoughts (Tracey, 2013). Interview questions were developed to explore the current viewpoints towards the use and management of sensitive conservation data. These questions were approved by the UGA Institutional Review Board and deemed non-human research. Despite this, anonymity will be maintained for those interviewed; to this end, identifying information was redacted during transcript curation.

Interviews (n=21) were conducted and recorded in person or via Zoom between July 2019 and September 2020 and transcribed with the Otter.ai application (Liang & Fu, 2022). Two interviewees requested not to be recorded and were excluded from analysis. However, notes taken during the two unrecorded interviews were used to formulate the discussion section and guideline recommendations. Interview transcripts were curated within the Otter.ai platform which mostly pertained of redaction, elimination of superfluous information; removal or recombination of incomplete sentences and thoughts into coherent, logical sentences; and grammatical correction (e.g., repetition, repeated words, incorrect tense, jargon, explanation of acronyms). This process is referred to as an edited transcription within qualitative research (McLellan et al., 2016). An example of the interview curation process is included in supplementary materials. After curation, thematic analysis, guided by inductive coding, was used to identify common themes across all interviews (Lecompte & Preissle, 1993). Interviews (n=19) were uploaded into Delve

coding software (Ho & Limpaecher, 2022). Relevant excerpts were identified line-by-line to generate *invivo* codes which were then categorized to generate themes. Themes were summarized to develop guidelines and best practices for data management. Four randomly selected interviews were sent to an external reviewer to create inter-rater reliability. Inter-rater reliability is a common practice in qualitative research in which a subset of the dataset is sent to people additional to those doing the research and they are asked if given the same input data that they come up with the same codes and themes identified by the researcher(s). After inter-raters have completed their coding and thematic analysis a conversation between the researcher(s) and the inter-rater(s) allows for correction and re-evaluation of all codes and themes to reach a consensus. The interviews from this study yielded 90% inter-rater reliability, but after discussion of discrepancies 100% inter-rater reliability was achieved.

## **Results**

Inductive coding of interviews led to three main themes related to data management guidelines and best practices including, 1. Resources (insufficient funding, infrastructure, and well-trained workforce), 2. Public engagement, and 3. A lack of opportunities for newcomers to the field of conservation. Data security is at the heart of several concerns expressed by participants and relates to all of the aforementioned themes. For example, participant 8 discussed this struggle,

*How can the conservation community work either with or better inform hobbyists, ecotourism groups, and people that are often well intentioned, but don't understand the impact of what they're doing? It's something that we struggle with as wildlife and conservation professionals. There's always this balance between how you get*

*people to care about things if they can't see or experience it. We want people to care about them. You can get into this situation however where people love things to death.*

These themes create a self-perpetuating loop of causes and issues that we believe plays a large role in the frustration with a lack of progress for data security expressed across most of our interviews (Figure 2.1).

The availability of resources was a major theme throughout all interviews. Resources can include but are not limited to workforce, funding, training, software, hardware, and standardized best practices. Lack of workforce is associated with barriers to entry for people wanting to become involved with conservation but are unable to for a myriad of reasons. Participant 9 provides much needed perspective of a conservationist working in the field and how a lack of resources (including workforce) directly impacts conservation efforts.

*We have 800 species that we track. I would say on average, we probably have seven or 10 EOs (element occurrences) for each taxon. For some we have 30 and some we have two. If you do the math, you're talking about 10,000 plant records probably or more. We can't get to all those. There are some sites that we haven't gotten to in almost a decade. There's only five of us and only so many days in the year.*

The main reason for this workforce deficit were limitations of time and resources for stakeholders to fulfill their management responsibilities, do outreach, stay current with technological developments and train new conservationists. For example, Participant 5 described how they have difficulty providing training as they lack the knowledge needed to work with the software.

*How do we address the difficulty and lack of training for ArcMap versus the ease of use and accessibility of Google Maps and the possibility of the data being made public via Google? That's a really good question because we have the same problems as the students not knowing or having training for the software.*

The industry standard hardware and software required for proper conservation data management are cost prohibitive for someone new to the field and often have a yearly fee to maintain use. This limits the ability of newcomers to teach themselves the proper techniques and software required to work in this field. Free and inexpensive open-source alternatives are often seen as less secure and difficult to use (Table 2 & 3). Participant 4 highlights the complexity of dealing with sensitive data in today's technological climate.

*With technology, it's super easy to put points on a map—much easier than it used to be and to share that. It's great, but at the same time, there are vulnerabilities. Google is the most capable, but also maybe in some ways, they're the most secure because they have the resources to maintain security. But also, they're so big that they're a target.*

Specialized software and hardware often require specialized training to use properly. Participant 1 describes how training would prepare users to better protect sensitive data.

*Using ArcMap and QGIS programs is difficult. Having these easier options, we need to make sure we teach people to take those extra steps, even though they're difficult, because it's for the sake of protecting these plants, or these locations.*

Most environmental and ecological scientists are willing to share their data, but they are challenged by a lack of experience with data management and insufficient training, an absence of easy-to-use metadata management tools, lack of awareness of standards, and

a deficiency in institutional support and resources for data management (Kervin et al., 2014; Tenopir et al., 2011). Participant 3 describes the problem:

*As a conservation biologist, we don't all work with endangered species per se. There are no courses on how to even create great metadata sets and post your data online, the way the National Science Foundation would like you to. I think we should have more courses just in general about data management, because you must sort of train yourself. In general, I think it is important. You find yourself studying a certain area of conservation, and then you get a big grant. Suddenly, you're in the situation where you must make your data available in some sort of a public way. I don't think we get enough instruction about that.*

Participant 2 shares how they were unfamiliar with the programs available to them and how that created a potential for a misuse of the information.

*When I got my first datasets from the Heritage Program, GIS files, I didn't know what they were. I had to look around, find that we had access to GIS here at the university, get them to install it on my computers in the laboratory, then I could load it and begin learning how to use GIS. What you're dealing with is that conservationists across the United States are all using GIS. So, you're stuck having to use their systems, even though Google Maps is so much easier.*

Another emergent theme was concern about insufficient support for newcomers to be successful in the field. Primarily there is limited funding and time available to properly train new conservationists. Further, those conservationists within these organizations that could train newcomers are dedicated to other efforts. Participant 13 suggests that this training fits more appropriately in the university setting.

*The universities need to pause and make sure that responsibility falls on the professors to share those guidelines [permits, ethics, private landowners]. The conservation ecology certificate, which is offered through the [redacted], is completely plant blind. We need to get this training back in. And not just at [my university], but all of them.*

Complicating the problem, when support is present for newcomers, best practices and training approaches differ widely between stakeholders. There is no standardized training available across agencies. All of this leads to a lack of opportunity for newcomer inclusion. Every state has different regulations regarding plants and listing of those plants. Participant 15 provides the perspective of a state-level conservationist.

*It gets back to the education. In the position of a state agency, we're not regulators, and we do need to be careful with the data that we share, but ultimately the data is for our people and the state. We're here to protect the state for the people.*

Participant 19 provides the approach of a federal-level conservationist. While their approaches overlap, the way in which this is implemented in the field is very different.

*Things that need to be included are an overview, not only in the Endangered Species Act, but also the safeties and implications for collecting sensitive species, transporting potentially sensitive species, or just working with said sensitive species. That's going to apply for those working with species in situ and in their countries of origin, as well as how you work with those species, including collections in the United States.*

Participant 13 has a more academic approach but has experience working with both state and federal conservationists.

*Not that I know of [referring to availability of training for use of sensitive data], and I think that just to get scientists to make their data available, has been the biggest push. The National Science Foundation now has rules that you must make your data available from the metadata, not because anybody's worried about revealing the location of endangered species, but so the information gets out there since it was paid for by taxpayer dollars.*

When newcomers do become involved with the field of conservation their experiences are often negative, mirroring that of current conservationists. Experience has taught conservationists to have a historic distrust of newcomers and the general public when dealing with sensitive species and data. Participant 13 details how they are cautious of newcomers because it can be difficult to fully recognize their intentions with protected species.

*I would say that the conservation community probably feels like it's been burned by poachers over decades of time. They're going to be cautious when someone comes forward. I would be cautious, especially if someone's got a horticulture background.*

This can lead to broken trust and limit relationships between conservationists and newcomers, as the impact of singular negative experience can be catastrophic for a plant species and therefore leads to wary conservationists. Participant 12 details how one mistake that compromises this data leads to a complete withdrawal from the system.

*You must go through the process to really gain that trust and establish the understanding of what you're going to do with the data and how you're going to do it. If you violate that, you're done. We can only provide a use notice, which outlines*

*how DNR advises that you use the data. We ask that you do XYZ to make sure the data is not distributed more widely. We wouldn't be able to seek any further action other than the permit would be revoked, since it's on our land, if a breach happens, by the very nature of it, it's public information. Technically, according to South Carolina, it's okay, but it's not from the welfare of the species standpoint.*

Participant 5 discusses how important trust is between conservationists and newcomers as data breaches pose serious threats to an ecosystem and therefore must be taken seriously when they occur.

*The permitting and data sharing process is an opportunity for permit holders to establish trust and establish a working relationship with these people that spend their lives dedicated to protecting these things. When that data or when that trust is breached, it's no joking matter. It's a very serious thing.*

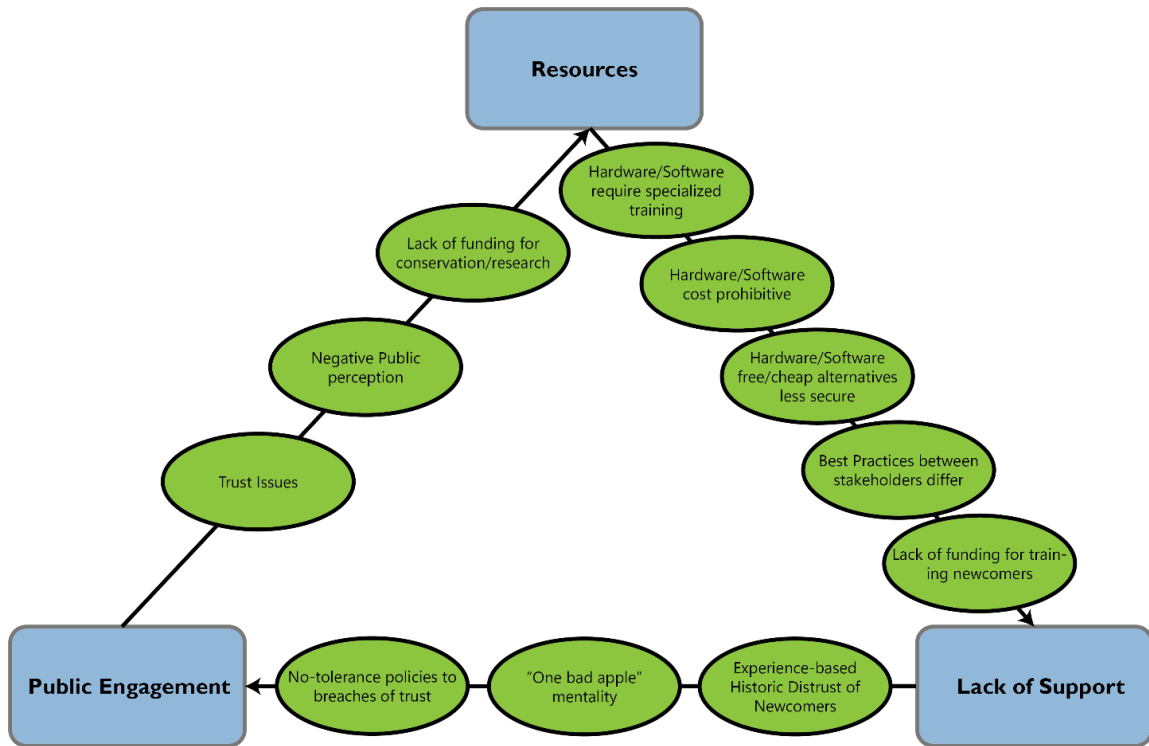
The lack of trust, workforce, and financial support fuels the conflict between expanding and achieving protection with public engagement. Inclusivity is viewed as a rite of passage to create a level of trust and an ethical relationship with the conservation community. However, the issue remains that the efforts to enhance and perpetuate these relationships are minimal. This mistrust can lead to a lack of engagement with the public which includes hobbyists, permit seekers, citizen scientists and laypersons in general. Most people are a threat to biodiversity in large part because of a lack of education and experience. Fundamentally education and training are central to resolving this issue.

Trust issues are central to this entire cycle as they lead to a negative public perception of conservation and when this trust is broken furthers negative experiences for those currently in the field This gap between conservationists and newcomers continues to

widen which in turn could lead to a lack of funding via taxpayer dollars for conservation and conservation research Perpetuating the issue of workforce in the field. Participant 16 explains the dilemma they consistently face

*The importance of realizing how tenuous these things are; they're right on the edge of extinction for a lot of these species. A lot of the trends are not going in a positive direction. Plants are winking out left and right. It's such crucial work. It's on a razor thin margin, done on shoestring budgets by a handful of people.*

This cycle of issues and their causes, without being broken, likely inhibits the progress and work of conservation stakeholders.



**Figure 2.1. Visualization of the cycle inhibiting progress in the field of conservation.**

Blue bubbles are the primary themes identified through thematic analysis which contain multiple known issues. Green bubbles are potential causes and results of these issues as identified by interviewed stakeholders. “Resources” can be more extensively defined as insufficient funding and infrastructure and “Lack of Support” is specifically referring to experiences of newcomers to the field of conservation. Newcomers being defined as anyone not professionally trained in the field of conservation and can include, but are not limited to students, nature enthusiasts, hobbyists, etc.

## **Discussion**

Establishing clear guidelines and best practices for all stakeholders is agreed upon as the best approach to data management by all interview participants. However, best practices differ between permit holders, permitting agencies and data repositories. To this end, the following guidelines were elucidated through these interviews and the resulting thematic analysis (Figure 2.1).

### **Guidelines For Permit Holders**

Conservation data management can be approached in either a proactive or reactive way. The results of this study show that current best practices are based on a reactive approach. It is our goal to encourage conservationists and newcomers to consider their approaches and revise policies to reflect a more proactive approach. Thematic analysis revealed that when asked about how to approach data breaches, all interview participants had suggestions that could be categorized as proactive or reactive (Figure 2.2). The guidelines developed as part of this study have been designed with these two primary approaches in mind.

Preparation for permit applications is a daunting task for newcomers, especially if the study system has a large geographic distribution. This often requires applications to multiple permitting agencies and appeals to private landowners (Supplementary Materials 4A).

	Permit Holder	Permitting Agency/Data Repository
Proactive	<ul style="list-style-type: none"> <li>•If using citizen science platforms (iNaturalist, Zooniverse, etc.) obscure personal identifying information and sensitive data</li> <li>•Develop an alternative naming scheme to hide locality data (e.g., number populations rather than using landmark names)</li> </ul>	<ul style="list-style-type: none"> <li>•Full awareness of conservation issues for a system</li> <li>•Only bring approved and listed people as on your permit</li> <li>•Understand the likelihood of poaching</li> <li>•The bigger the threat, the more time permitters spend focused on the system</li> <li>•Sign a data sharing agreement to demonstrate understanding and provide the agency/repository with recourse should a breach occur</li> <li>•Bad gut feelings or requesting too much information are red flags to permitters</li> <li>•Send permit requestors to get landowner permission before granting a collection permit - if they plan to poach they probably won't follow through</li> <li>•Require extensive explanations of project and justification of need</li> <li>•Help refine projects to minimize data sharing required</li> <li>•Sign a terms and conditions agreement that clearly lays out expectations for what is and is not okay to do with data shared as part of the permit</li> <li>•Remove geo-location on any photos or videos taken at sensitive locations</li> </ul>
Reactive	<ul style="list-style-type: none"> <li>•If a data breach has happened, remove any of the hosted data immediately</li> <li>•It's hard to know how to lessen the impact, since you don't really know how great it is to begin with in some cases.</li> </ul>	<ul style="list-style-type: none"> <li>•Establish facts by reaching out to data breach sources (permit holder &amp; affected stakeholders)</li> <li>•Reassess how information is communicated and shared</li> <li>•Identify weakspots in security</li> <li>•Ask yourself if it is clear to everyone with access to sensitive data how serious it is to maintain security <ul style="list-style-type: none"> <li>•Not just something proprietary or a little upsetting were it to be leaked</li> <li>•Data security is high stakes and could lead to extinction of populations and eventually species</li> </ul> </li> <li>•Increase caution</li> <li>•Discuss with other stakeholders (permitting agencies, data repositories, experts in the field)</li> <li>•Weigh options before reacting (e.g., how would revoking data access impact the permit holder's goals or is this an opportunity to improve security?)</li> <li>•Trust established relationships and don't assume the worst if a breach occurs</li> </ul>

**Figure 2.2** Suggestions from interview participants for proactive or reactive strategies for minimizing data breaches. Bullets are paraphrased from quotations from interview participants 2, 5, 7, 9, 10, 12, and 15.

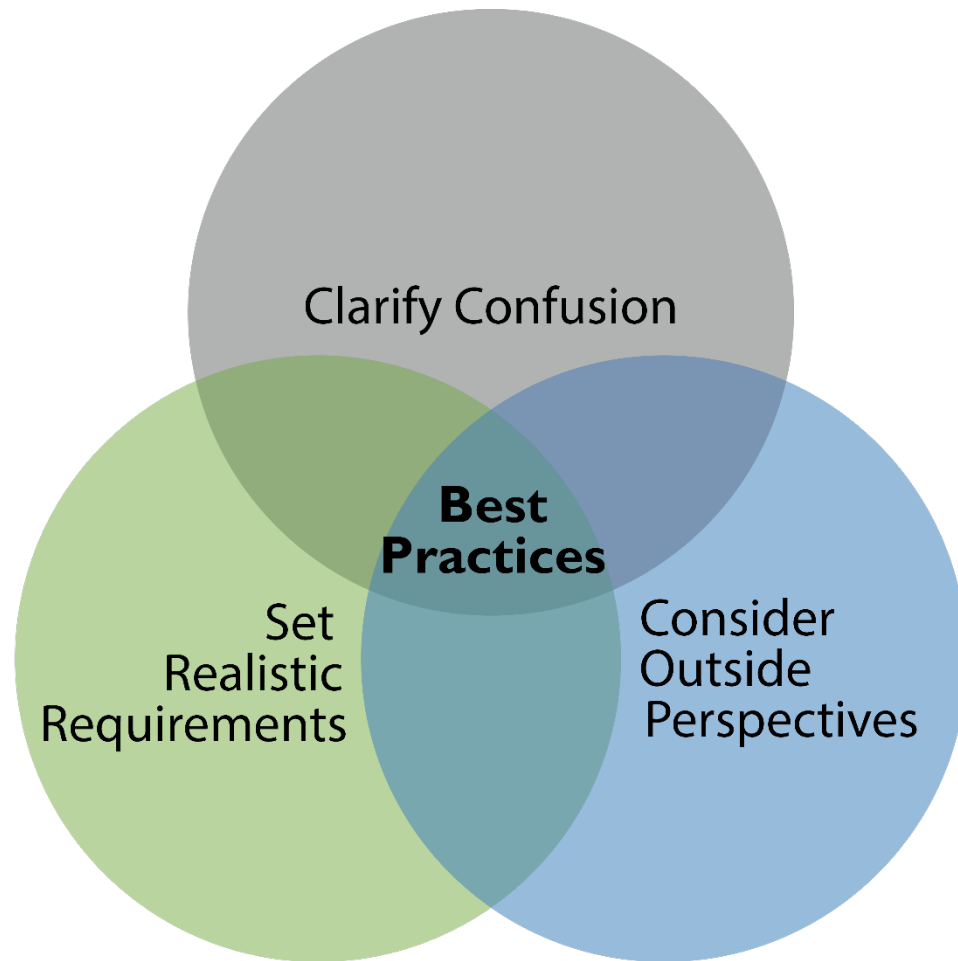
All interviewees expressed a need to streamline and improve the permitting process to facilitate accurate and complete applications to eliminate extensive effort for even minor requests. In addition, they recognized an intrinsic relationship between the breach or exposure of location data, which is a subset of data management, to poaching and the loss of the protection of threatened species as being the key to biodiversity loss and protection. There is no best practice recognized by the interviewees, simply suggestions and a divided opinion regarding whether open sharing of a location is already public knowledge. Best practices may include signing data sharing agreements, Non-Disclosure Agreements (NDAs), location obscuration/redaction, use of GPS and GIS Maps, and social media awareness (something as simple as how to turn off geo-location on mobile phones). Most were insistent that they wanted education and training for responsible data sharing of sensitive and protected species and the importance and significance of violating those regulations, ethics, the permitting process, and understanding of the rights of landowners.

Permit holders/applicants were unaware of how in-depth their knowledge of conservation issues was expected to be by permitting agencies and data repositories. We developed guidelines intended for adaptation and dissemination to potential permit seekers by Permitting Agencies and Data Repositories to make the permitting process more transparent and straightforward (Supplementary Materials 4B).

However, there is a lack of certainty as to who should be responsible for training those entering the conservation workforce. There is interest within academia to take on this role. The University of Georgia as an example, is on the right track to implement such training through initiatives like the Integrative Conservation (ICON) program, and the graduate certificate in Conservation Ecology. However, interdisciplinary programs like

these are not universal across the life sciences and increased interpersonal, interdepartmental, and intercollegiate communication is necessary to ensure the efficacy of these training opportunities. While efforts like these are commendable, conservation data management is rarely included as part of the curriculum.

We have developed a three-step process to the creation of utilitarian guidelines for conservation data management primarily for use by Permitting Agencies and Data Repositories (Figure 2.3). Step one is to clarify any points of confusion for permit holders, whom to contact for this process, what requires permits or agreements, what those permits or agreements cover, and what is needed to properly apply. Step two is to consider outside perspectives such as those of the permit holders and other stakeholders which can provide valuable perspective for the next step, setting realistic requirements. Requirements should provide the permit holder and the permitting agency or data repository with the opportunity to establish a clear understanding of goals, how the shared data or collected samples will be used, sources of funding, where vouchers will be deposited, and most importantly a demonstration of understanding for the threats the organism currently or historically has faced.



**Figure 2.3.** The Clarify Confusion, Consider Outside Perspectives, Set Realistic Requirements (CCR) model of best practice creation. By combining all three approaches one can create meaningful best practices.

The guidelines we propose are a small sample based on our experiences completing this study and are not intended to be an exhaustive list. The field of conservation is ripe with opportunities for improvement. Ideally, a single landing platform for all stakeholders could be developed that functions as a one-stop shop for conservation data training, permitting, and contacts. Such a website could contain guides on what is required to obtain each type of permit for each permitting agency or data repository; contact, training, and permitting forms that once completed are automatically submitted to the appropriate stakeholders; and regularly updated contact information for stakeholders at all levels of conservation (local, state, federal, non-governmental, academic, etc.). This study barely scratches the surface of but a small portion of it. It is our hope that by collating this information we enable those involved to improve conservation efforts and prevent further harm to all threatened species more effectively.

*“The ultimate goal of any work with sensitive species is to further their protection.”* – Participant 13

### **Supplementary Materials**

#### **S.1 Ethical Assurances and Subjectivity Statement**

This research does concern the privacy of individuals; however, the Human Subjects Office for the University of Georgia deemed the study *exempt* from institutional review because of the nature of the interview questions. I have maintained all interviews and subsequent analyses on my personal computer and did not publish any identities within my manuscript.

In addressing inherent bias and subjectivity in this study, I am coming from the perspective of a permit holder and a current student at the University of Georgia. My degree program sometimes utilizes sensitive conservation data but there is no formal training in place currently on how to handle this sort of data. My undergraduate degree was in horticultural science and a minor in agricultural business management and I was heavily involved in the hobbyist community for carnivorous plants for the past decade. I am currently a doctoral candidate in the Department of Plant Biology at the University of Georgia. I have earned the graduate Certificate in Conservation Ecology and the graduate Certificate in University Teaching during my time here.

The planned focus of my dissertation was Taxonomic Delineation using Modern Genetic and Traditional Morphometric Methods in *Sarracenia* (Sarraceniaceae). However, after an online map full of locality data in my care was accidentally made public the permits I had been granted were revoked and my dissertation focus switched away from rare species (*Sarracenia*) and instead focused on taxonomic delimitation using a common species (*Cercis*). This data breach caused great harm to myself, conservation stakeholders, and the populations of *Sarracenia* exposed by this data breach. For those that were affected please know that this breach was unintentional, and this study came about to attempt to make the best of a bad situation with numerous rounds of input directly from those that were most affected by it. While these characteristics about me and my life should not affect the analyses within this study, they inform and guide the recommendations made within this paper.

## **S.2 Email sent to prospective interview participants:**

Dear \_\_\_\_\_,

As you may know, last year a map I had compiled with sensitive location data for *Sarracenia* populations was accidentally made public. Such data breaches have far-reaching implications for many stakeholders including yourself. I want to begin by apologizing for this breach of trust. Since this data breach/leak occurred, I have been taking multiple steps to better educate myself and others (when appropriate) on how to avoid similar circumstances from occurring in the future. This includes completing the [Conservation Ecology Certificate Program](#) at UGA and reformulating my dissertation plans to include a chapter on conservation data management. I am reaching out to you to humbly request your participation in a survey that I am conducting to gather information on considerations for formulating digital conservation data management plans.

I am seeking input from stakeholders in conservation organizations including the state DNRs, USFWS, non-profits, and academia to gain a comprehensive perspective of data management hygiene and the negative impacts of data breaches. Additionally, I am compiling information on how stakeholders have historically managed the security of locality data for imperiled populations.

To this end, I would greatly appreciate the opportunity to interview you for this study. I have attached the project abstract as well as sample questions I would like to explore in an interview. If you are willing, the interview will be conducted and recorded via Zoom. I appreciate your consideration of this request, and I look forward to speaking with you further regarding this important issue for conservation of imperiled species.

### S.3 Interview Questions

Permitting Agencies	Permit Holders	Data Repositories
<ul style="list-style-type: none"> <li>• Can you briefly summarize the process for obtaining sample collection permits from your organization?</li> <li>• Who typically applies for collecting permits to work with imperiled populations, and how do you decide whether or not to grant a permit?</li> <li>• How often do data breaches occur and how are they addressed? After they occur, how do they shape your approach to permitting and data sharing?</li> <li>• If a training module were developed with your organization's input, would you consider implementing it as part of permit allocation process?</li> <li>• What can permit granters and permit holders do to reduce the probability of data breaches and if they do occur what can we do to lessen the impacts?</li> </ul>	<ul style="list-style-type: none"> <li>• What experience did you have with conservation data prior to applying for permits?</li> <li>• What was your experience applying for permits?</li> <li>• How is the data you received from permit providers used?</li> <li>• What steps are you/did you take to reduce the probability of a data breach?</li> <li>• If a training module were developed for permitting organizations, what do you think that should look like?</li> </ul>	<ul style="list-style-type: none"> <li>• How does your organization handle the sharing of data for rare or threatened species?</li> <li>• What steps do you take to reduce the probability of data breaches or the unwanted sharing of sensitive data?</li> <li>• If a training module were developed for people requesting data from permitting organizations and data repositories, what should that look like and would you consider implementing it as part of your data sharing process?</li> </ul>

### S.4 A. Guide to Materials for Permit Applicants

- Full project proposal
  - Minimum 2 pages single spaced not including figures or a reference section
  - A full list of personnel that will be involved with or have access to the data acquired throughout the project (permitting agencies understand this may change over time)
  - A well-developed budget including travel expenses, material costs, wet-lab costs, personnel costs, and current or potential sources of funding
  - Project proposals should demonstrate
    - clear and concise goals for the study
    - expected outcomes/hypotheses and their benefit for the study system or stakeholders

- methods for harvest from the field including precise quantities required and what will be done with samples during and after study completion
  - timeline of study
  - specific locations you plan to sample (may not be possible until initial permit request is made)
  - understanding of the historic risks your study system has faced
  - appreciation and acknowledgement of previous and ongoing work on researching and protecting your study system including citations and project contacts (for ongoing work)
  - the need for collection and how removing material from the population(s) is worthwhile
  - specific steps you plan to take to minimize impact on the study system including at the individual, population, and whole ecosystem levels
  - understanding of your responsibility in safeguarding your study system including but not limited to location data, responsible harvesting, and trust between you and other stakeholders (researchers, landowners, conservationists, etc.)
- Brief project proposal
  - Maximum 2 pages including figures & references
  - Bulleted goals and expected outcomes of the study
  - Anticipated benefits of the study

- Expected impacts on stakeholders
- Should be in plain language so that anyone can understand what is being done (avoid jargon or complex concepts)
- Signatures and contact information for the PI (Principal Investigator) and whomever is doing the field work
- Bring copies of this into the field to give out
- Curriculum Vitae

#### **S.4 B. Guidelines for Permitting Agencies and Data Repositories**

- Design the permitting process with the applicant and downstream use of the permitting process in mind
  - Establish trust
  - Use as a teaching opportunity
  - Use concise, plain language (avoid jargon and legalese)
- What is the permit for (3 main types)?
  - Data sharing
  - Land Access
  - Material Removal or Reintroduction
- What about this application could be confusing to unfamiliar applicants?
  - Relevance of local, state, or federal laws
  - Purpose of the questions being asked
  - Identification of the main contact and decision maker
  - Collection guidelines

- o Data management, including data sharing/data protection guidelines
- o Responsibility to submit results, including completeness, formats and timing
- o Why only GPS and GIS Maps are available
- What specific forms must be signed by the applicant and why? Include as appropriate:
  - o Data use notice determines specifically how the location data and sensitive data must be treated
    - Identification of specific locations (federal, private, state)
    - Applicable statutes and access to sensitive information
  - o A confidentiality agreement (also called a nondisclosure agreement or NDA, sensitive data agreement, waiver of nondisclosure, etc.)
    - a legally binding contract in which a person or business promises to treat specific information as a trade secret and promises not to disclose the secret to others without proper authorization
    - binds the applicant to the obligations and ramifications of a data breach, including but not limited to possible permit revocation or legal action
  - o Terms and Conditions govern the contractual relationship between the permitting agency and the applicant which includes:
    - Agreement to share results, locations and published documentation including location obscuration

- o Material Transfer Agreement is a contract that governs the transfer of tangible research materials between two organizations when the recipient intends to use it for his or her own purposes.
- What proves the applicant is a responsible conservationist?
  - o Curriculum Vitae
  - o Documentation of relevant experience
  - o Previous publications on the species
  - o Published species recovery plan with a specific beginning and end tied to the recovery plan or five-year review documents
  - o Inclusion of justification and rationale to show a net conservation gain that moves us towards recovery goals for that species
    - If Federal permit would then include:
      - Federal Register Notice
      - Public Comment
  - o Statement of understanding of the level of threat to the specific species involved including poaching
  - o Understanding of the Endangered Species Act (ESA) and/or Wildflower Preservation Act and what is strictly prohibited or permitted
- How long does the permitting process take once the form is submitted?
  - o Include next steps as a bulleted list or decision tree on the form
  - o List stakeholder dependencies based on type of permit, examples:
    - 60 days for public comment

- Land manager inclusion (number of business days)
  - Landowner permission pending (number of business days)
  - o Provide seasonal window to expedite permit applications (best times to apply)
- Who owns the execution of and responsibility for the permit upon approval?
  - o The role of collaborators or sub-permittees
  - o Data breaches defined, how to prevent and how to remediate if one happens
  - o Review

## CHAPTER 3

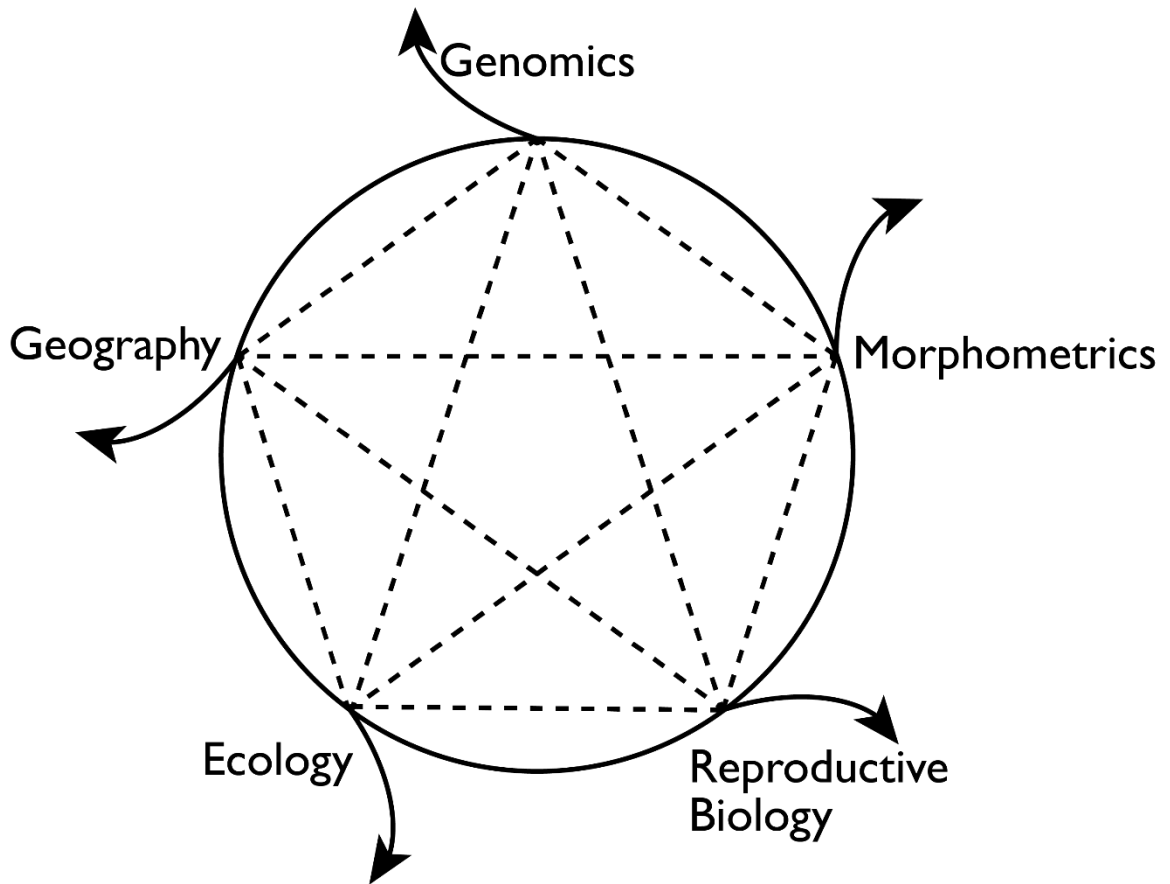
### MORPHOMETRICS OF *CERCIS CANADENSIS* L.

#### **Introduction**

Morphometrics, the quantitative analysis of form, has historically been the primary source of information used for taxonomic delimitation. With increasingly high-resolution genetic and genomic information, taxonomists are faced with the daunting task of reconciling historic taxonomic delimitation with genetic and genomic data, reproduction, ecology, and geography. These issues are summarized by DeSalle et al. (2005) as the “taxonomic circle” which they contend those working on taxonomic delimitation must break free of to avoid circular or tautological reasoning (Figure 3.1). While an oversimplification of their important work, they propose the best way to break free of the taxonomic circle is to combine multiple approaches to taxonomy rather than relying on a single method. This philosophical approach has been described previously as the Pluralistic Species Concept (Cummings et al., 2002; Mishler & Brandon, 1987; Mishler & Donoghue, 1982). Regardless of the concept applied, the tenets of this approach can be simplified to: use as many sources of evidence as possible when delimiting taxa. Attempts to reconcile combining data sources (DNA, morphology, reproduction, ecology, geography) are already underway (Jackson, Carstens, et al., 2017; Jackson, Morales, et al., 2017; Smith & Carstens, 2018; Sukumaran et al., 2019). In an ideal situation all aspects of the taxonomic circle would be considered for a truly pluralistic taxonomic delimitation.

Fritsch et al. (2018) provided an ideal platform for incorporating a pluralistic species concept approach by exploring phenotypic variation of North American *Cercis* using morphometric approaches on herbarium specimens. Their initial genetic work also provided insight into delineating seven taxonomic “working groups” but acknowledged that more work was required before a revision of taxonomic circumscription within the group could be justified as rigorous and robust. Specifically, determining the degree to which the traits used to distinguish taxa stand up in the face of variation in growing conditions would be of particular importance.

Common gardens provide a robust approach to assessing the effect of environment on morphological characters (Clausen et al., 1939). Clausen et al. (1939) suggest that environmentally driven variation in phenotypic characters, i.e. plastic traits that change based on the environment in which the organism is grown, are considered inappropriate for use in delimiting species. By analyzing the traits identified by Fritsch et al. in a common garden setting, the taxonomic rank of their proposed taxonomic working groups can be investigated more deeply.



**Figure 3.1** The taxonomic circle adapted from De Salle et al., 2005. The dotted lines that traverse the inner part of the circle indicate experimental routes that can be taken in taxonomic endeavor to accomplish corroboration of taxonomic hypotheses. The only way to delineate a new taxon according to De Salle et al. is to break out of the circle by incorporating at least two of the approaches (the solid arrows emanating from the circle) in experimental design. The Pluralistic Species Concept considers each of these dimensions. For example, phylogeographic or ecological niche studies could integrate geographic and genomic information.

## Taxonomic History

The genus *Cercis*, like many genera, is fraught with taxonomic controversy over species and subspecies designations. Circumscriptions of species, subspecies, varieties, and forms of North American taxa are hotly debated in the taxonomic and horticultural literature. Linnaeus describes *Cercis canadensis* as having “*foliis pubescentibus*” or pubescent leaves. As remarked by nearly every botanist that has published a taxonomic treatment of North American *Cercis*, the dominant phenotype of this species throughout its range (Figure 1.2) is nearly entirely of glabrous foliage, rarely with sparse hairs in the axils of the leaf veins but only on the underside of the leaf blade (abaxial) (Fritsch et al., 2018; Gray, 1850; Green, 1912; Hopkins, 1941; Metcalf, 1940; Tidestrom, 1941). Subsequent taxonomic descriptions have attempted to delineate using the habitat types, vegetative, floral, and fruit phenotypes found across *Cercis canadensis*' natural range. The most important traits historically recognized are leaf pubescence, thickness, glossiness, and shape (base & apex); fruit size and pubescence; flower size and color; and overall plant habit (shrub or tree). The consensus among those working with North American *Cercis* is that there are at least 5 distinct taxa within North American *Cercis* which were well defined by Fritsch et al. (2018) as taxonomic working groups (Table 1.1). The most recent taxonomic treatment recognizes two species and three varieties, and a cryptic species segregating within *C. occidentalis* has been hypothesized (Fritsch et al., 2018; Hopkins, 1942b). Fritsch and coauthors performed a comprehensive morphological analysis of leaf and flower traits together with internal transcribed spacer (ITS) and chloroplast gene-based phylogenetic analyses. They identified a cryptic species within *C. occidentalis* and asserted it should bear the name *C. orbiculata* Greene. At the same time,

Fritch et al. lump populations with narrowly overlapping or distinct morphometric traits into *C. canadensis*, recognizing them as varieties within *C. canadensis* rather than species.

The objectives of this study are to use common garden *Cercis canadensis* to confirm whether the traits measured by Fritsch are robust to environmental influence via a common garden, expand upon Fritsch's morphometrics using an infraspecific hybrid F2 breeding population (*C. c. var. canadensis* X *C. c. var. texensis*), and verify traits historically used for taxonomic delimitation of *Cercis canadensis* varieties are legitimate through statistical analyses like principal component analysis.

## **Methods**

### **Sampling**

Pressed specimens were created for every accession (13) of *Cercis canadensis* with known provenance (Table 3.1) at the JC Raulston Arboretum (Raleigh, NC) with plans to expand to include accessions of every species of *Cercis* grown in the garden in the future. Pressings were made for each specimen multiple times throughout the growing season to capture vegetative, floral, and fruit characteristics. A full list of accessions sampled is included in Table 3.1.

**Table 3.1** Accessions of *Cercis canadensis* sampled from the JCRA common garden.

<b>Name</b>	<b>Provenance</b>	<b>JCRA Collection Number</b>
<i>Cercis canadensis</i>	Raleigh, NC	050030
<i>Cercis canadensis</i> “Large Leaf Form”	Raleigh, NC	950423
<i>Cercis canadensis</i> f. <i>alba</i>	Raleigh, NC	970717
<i>Cercis canadensis</i> var. <i>canadensis</i> ‘Ace of Hearts’	Morganton, N.C	040037
<i>Cercis canadensis</i> var. <i>canadensis</i> ‘Appalachia Red’	New Jersey	100164
<i>Cercis canadensis</i> var. <i>canadensis</i> ‘Flame’	Illinois 1902	990614
<i>Cercis canadensis</i> ‘Floating Clouds’	Iva, SC	050027
<i>Cercis canadensis</i> var. <i>canadensis</i> ‘Hearts of Gold’	Greensboro, NC	040050
<i>Cercis canadensis</i> var. <i>canadensis</i> ‘Royal White’	Parent Bluffs, IL	050043
<i>Cercis canadensis</i> var. <i>canadensis</i> ‘JN7’ = Summer’s Tower	Belvidere, TN	160476
<i>Cercis canadensis</i> var. <i>texensis</i> ‘Oklahoma’	Arbuckle Mtns, OK	090011
<i>Cercis canadensis</i> var. <i>texensis</i> ‘Texas White’	Madrone Nursery, Oklahoma or Ft. Worth, Texas	110240
<i>Cercis canadensis</i> var. <i>texensis</i> ‘Traveller’	Madrone Nursery, San Marcos, TX	190271 960536

Pressed specimens were also prepared for 163 F2 genotypes from a breeding population developed by Dr. Dennis Werner and grown at the North Carolina State University Sandhills Research Station (NCSU, SRS; Jackson Springs, NC). The F2 breeding population was created by crossing *Cercis canadensis* var. *canadensis* ‘Appalachia Red’ (mother) with *Cercis canadensis* var. *texensis* ‘Oklahoma’ (father) to create an F1 population. The F1 siblings were then crossed with each other to create the F2 seed. Selfed *Cercis canadensis* seed is generally weaker than outcrossed seed and *Cercis canadensis* is largely self-incompatible (pers. comm. Dr. Dennis Werner). F2 plants were germinated in a greenhouse at North Carolina State University (NCSU) for two growing seasons before being planted in four rows at the Sandhills Research Station (n=451). Plants grown at the Sandhills Research Station (SRS) were never pruned or fertilized during their lifespan but were watered consistently to maximize survival. After growing in the field for two years (total age of 4 years) we sampled trees for vegetative specimens removing two leaves and approximately six inches of the newest growth from a single branch of each tree sampled. During the same season it was noted that only approximately 1/5 of the F2 plants were mature enough to produce flowers and none produced fruit. In March of the 5<sup>th</sup> year of growth (2022), 422/451 plants bloomed. All blooming plants were photographed with a color and size standard for morphometric and color analysis and pressed specimens were made of a large subset of specimens prioritizing plants with previous vegetative specimens. When possible, at least nine fully open flowers were sampled and pressings were made over two trips approximately two weeks apart (March 28, 2022 & April 08, 2022). Two additional trips were made to the SRS to obtain vegetative and/or fruit specimens for all accessions with floral or vegetative specimens from prior trips. Measurements of tree

height, tree width, and distance to the first major branch were taken manually or using size-standardized photographs for all accessions sequenced.

Specimens were pressed in the field and returned to the GA Herbarium for processing. In total, 140 F2 accessions were sampled with two herbarium sheets per accession (n=280) and submitted to the GA Herbarium. All specimens were dried, mounted, digitized, and accessioned using standards used by the GA Herbarium. Images of all pressed specimens are available by request or via the SERNEC portal.

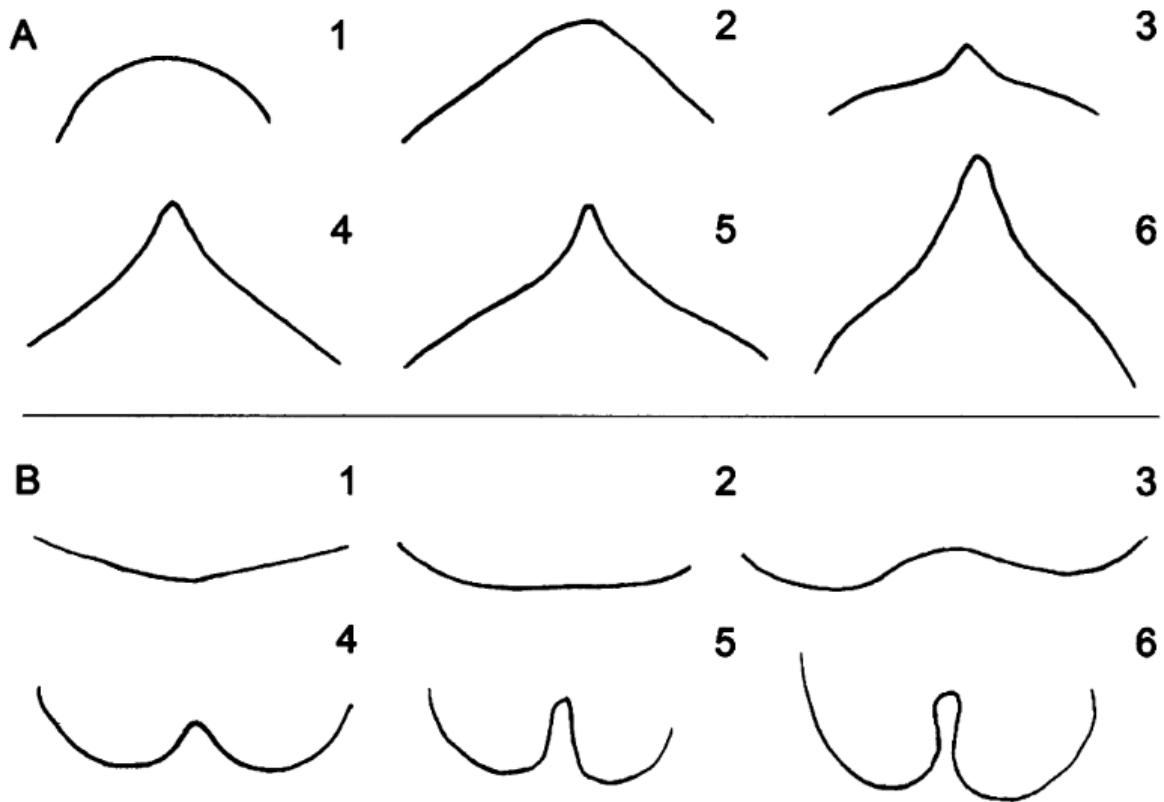
### **Morphometrics**

Traits for morphometric analyses were chosen primarily based on Fritsch et al.'s recent study on leaf adaptations but also based on historic approaches to taxonomic delimitation of North American *Cercis* (Burns & Raulston, 1994; Fritsch et al., 2009, 2018; Hopkins, 1942a; Plummer, 1954; Tidestrom, 1941). Measurements were taken directly from living plants, from photographs of living plants with a color and size standard, or from images of pressed specimens with a color and size standard (Table 3.2). Measurements from images were taken using imageJ for all traits except flower color (protocol in supplemental materials) (Rasband, 2018). Under my direction, multiple undergraduate researchers measured the traits from the images, but each trait was only measured by a single person to avoid potential bias in the data.

**Table 3.2.** Morphometric traits measured as part of this study. The source of the trait, and the source of the measurement. \*Trait only measured for F2 population and F0 parents

<b>Trait</b>	<b>Source of Trait</b>	<b>Measurement Source</b>	<b>Method Details</b>
<b>Leaf Thickness</b>	Historic	Live Plant	Measure from tip of leaf apex, avoiding overlap of major veins
<b>Leaf Sinus Shape</b>	Fritsch et al., 2018	Digital Image (Pressed Specimen)	From the two largest leaves on the specimen; (Figure 3.2)
<b>Leaf Apex Shape</b>	Fritsch et al., 2018	Digital Image (Pressed Specimen)	From the two largest leaves on the specimen; (Figure 3.2)
<b>Leaf Width</b>	Fritsch et al., 2018	Digital Image (Pressed Specimen)	From the two largest leaves on the specimen
<b>Leaf Length</b>	Fritsch et al., 2018	Digital Image (Pressed Specimen)	From the two largest leaves on the specimen
<b>Leaf Glossiness*</b>	Historic	Live Plant	Visually noted by one person and confirmed by a second; unable to consistently identify after pressing
<b>Flower Length</b>	Fritsch et al., 2018	Digital Image (Pressed Specimen)	Measured from the tip of the keel (lower petal) to the base of the calyx; minimum of three flowers per specimen; flowers pressed not with a side view avoided
<b>Flower Color*</b>	Historic	Digital Image (Live Plant)	Images standardized using Xrite color checker, segmented using Ilastik, then analyzed using the ColorDistance R package
<b>Fruit Length</b>	Fritsch et al., 2018	Digital Image (Pressed Specimen)	From tip of fruit to attachment of pedicel to persistent calyx
<b>Fruit Width</b>	Fritsch et al., 2018	Digital Image (Pressed Specimen)	From edge of fruit to edge of fruit wing at the widest point for the entire fruit
<b>Fruit Wing Width</b>	Fritsch et al., 2018	Digital Image (Pressed Specimen)	From edge of fruit wing to the middle of primary suture
<b>Tree Height*</b>	Historic	Live Plant/Digital Image (Living Specimen)	From tip of highest branch to where trunk meets ground
<b>Tree Width*</b>	Historic	Live Plant/Digital Image (Living Specimen)	From tip of longest branch on left side of tree to width of longest branch on right side of tree; measured perpendicular to ground

Height of 1 <sup>st</sup> Major Branch*	Historic	Live Plant/Digital Image (Living Specimen)	From where trunk meets ground to middle of the first major branch coming off the primary trunk
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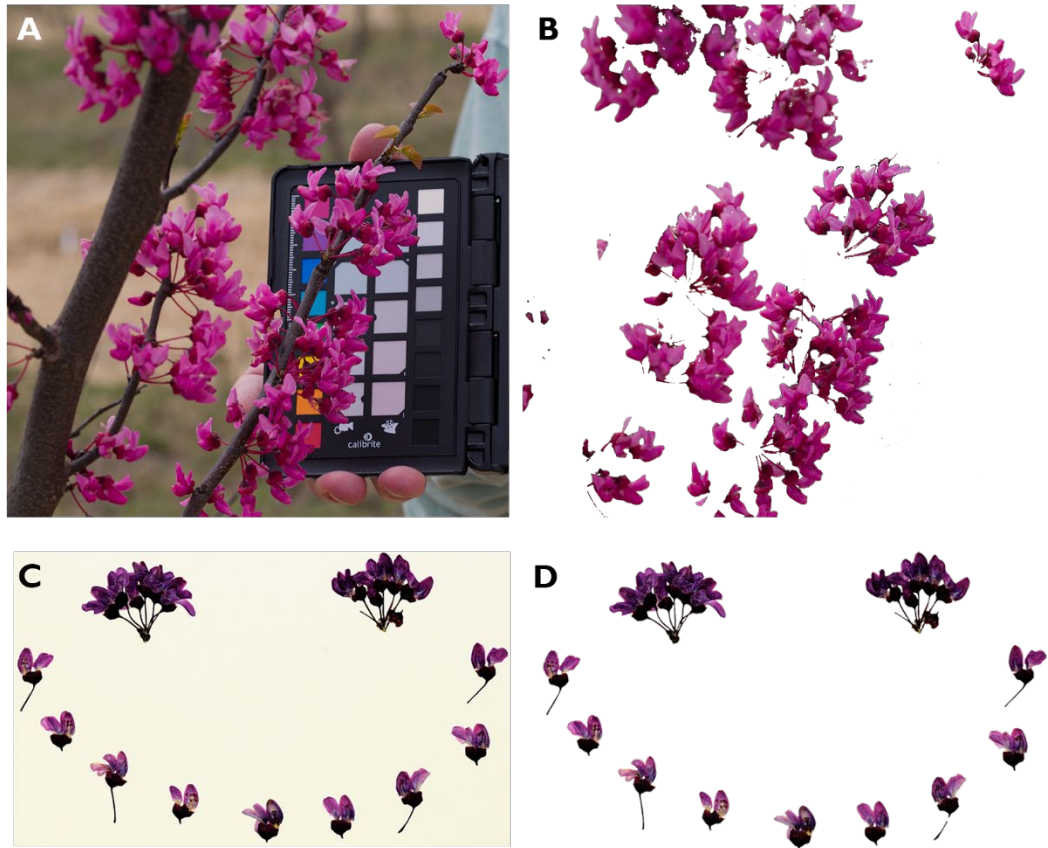


**Figure 3.2.** A. Leaf apex shape scale (adapted from Fritsch et al., 2009) B. Leaf Sinus Shape (adapted from Fritsch et al., 2009)

## Analyses

Traits from the JCRA common garden were combined with data for wild accessions measured in Fritsch et al., 2018, and analyzed using a principal component analysis (PCA) in R (Figure 3.4). Traits for which two or more measurements were made were averaged, and all measurement data were standardized ( $Z=[X-\mu]/\sigma$ ) prior to running the PCA. The same set of traits were measured for the F2 population with the addition of tree height, tree width, branch height, and leaf glossiness. All traits measured for F2 accessions were included in a second PCA (Figure 3.5).

Floral color was analyzed for all F2s that bloomed using a novel computational pipeline combining multiple pre-existing applications. Images taken of the flowers on live plants at the SRS and images of pressed specimens were analyzed separate and together. The drying, mounting, and storage process for herbarium specimens affects the color of both vegetative and floral tissue even over short spans of time (Figure 3.3). Color correction allows for a more comparable dataset by helping remove excessive changes in color from environmental variables.



**Figure 3.3** Images of flowers of F2 plant 4-102 used in color analysis. **A)** Unprocessed color image of live flowers taken at the field site. **B)** Color corrected and segmented version of image shown in A. **C)** Unprocessed color image of dried, pressed, and mounted flowers from the same plant 60 days later. **D)** Color corrected and segmented version of image shown in C.

Images of live plants were taken with a Canon 5D Mark III camera and a 50mm portrait lens in full-frame mode with manual f-stop and exposure times to obtain as similarly exposed images as possible. Because the live plants were growing in an open field, images were taken as quickly as possible to attempt to minimize variation in lighting due to time of day, cloud cover, and other factors. Because light conditions change over time it is important to note that due to the number of plants, imaging took nearly 3 hours to complete. Herbarium specimen images were taken with a Nikon D3x and 60mm lens with settings of f-stop of 13, 1/15s exposure time, ISO 100, and a standardized lighting setup. Raw format images were then color corrected using Xrite ColorChecker Camera Calibration software and Adobe Lightroom (live flower images) and an established image correction pipeline used in the GA Herbarium (pressed flower images) (Calibrite, 2021). Ilastik (Berg et al., 2019) was used to create training sets of 12 images each (live and pressed) for image segmentation. The training sets were then used to batch segment the remaining images in Ilastik. The resulting black and white segmented images were then used as masks in Adobe Photoshop to remove all parts of the images except the flowers (Figure 3.3 B and D).

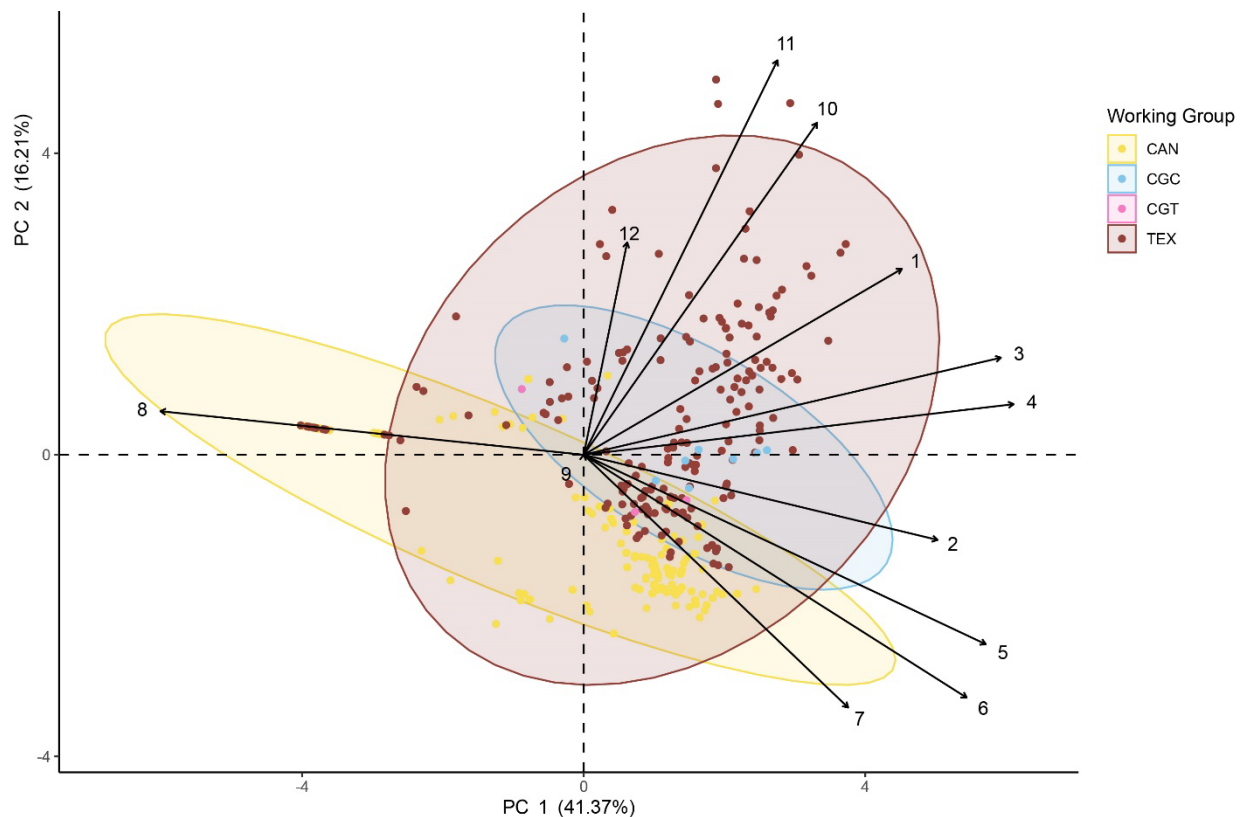
The resulting data sets (live and pressed) were then analyzed in Rstudio using the *colordistance* package (R Core Team, 2019; Weller & Westneat, 2019). *ColorDistance* enables the user to compare complex images by treating each image as a set of three-dimensional points where each pixel in the image is a coordinate of RGB or HSV color space. By binning pixel coordinates into a 3x3 matrix for each image, it then calculates distance between each pair of images based on the quantity of pixels for each color bin.

Further analyses to explore color distance results included non-metric multi-dimensional scaling (NMDS) and principal components analysis (PCA).

## **Results**

### **Common Garden Morphometrics**

Principal component analysis of 381 accessions of *Cercis canadensis* including 193 *C. c. var. canadensis* and 188 *C. c. var. texensis* revealed multiple correlations between measured traits except flower color (Figure 3.4). The wild accessions of *C. c. var. texensis* (TEX) from Fritsch et al. 2018 encompass all the common garden *C. c. var. canadensis* (CGC) and most of wild *C. c. var. canadensis* (CAN). However, wild and common garden *C. c. var. canadensis* (CGC) show little overlap. Common garden *C. c. var. texensis* (CGT) falls squarely within all three ellipses. Principal component one accounts for 41.37% of observed variation while principal component 2 accounts for 16.21% of observed variation.

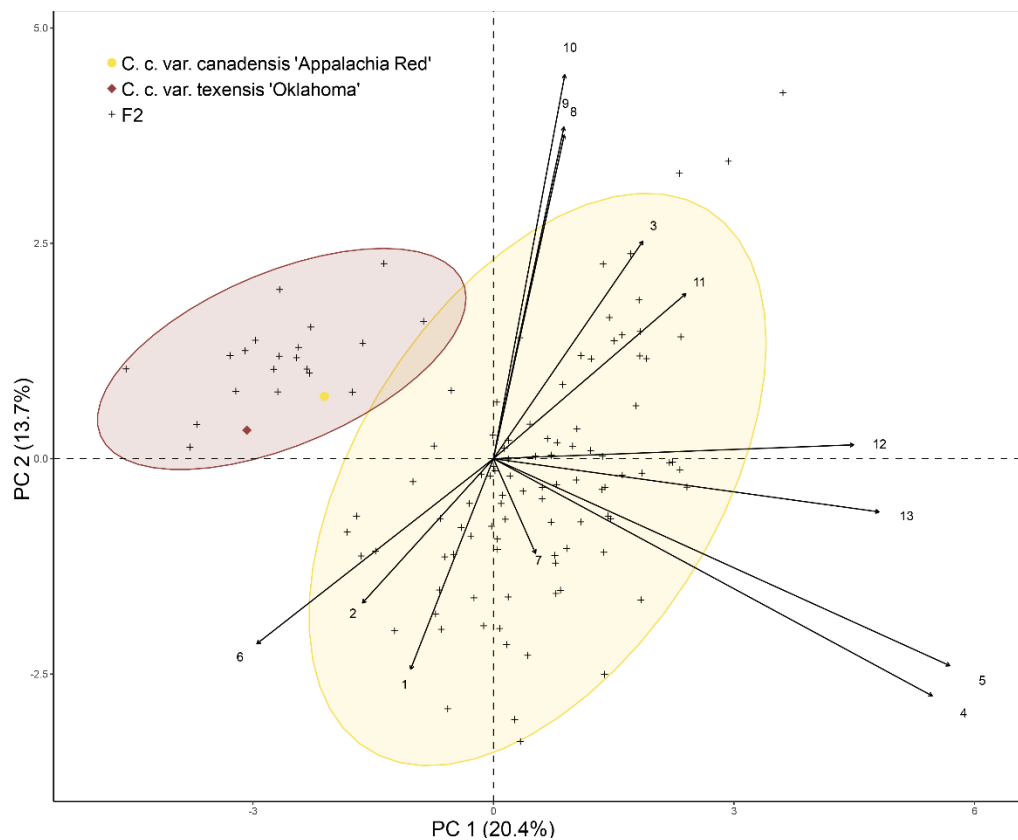


**Figure 3.4** PCA of plants grown at the JCRA (common garden) and those from the Fritsch et al., 2018 dataset (herbarium specimens for wild collected *Cercis*). The CAN (yellow) and TEX (maroon) working groups are from Fritsch et al., 2018. The CGC (blue) and CGT (pink) working groups are from the common garden. Ellipses are based on individuals within working groups. CGT does not have an ellipse because there are only three individuals from that group. Component loadings shown as black arrows: 1 – Leaf Apex Shape, 2 – Leaf Sinus Shape, 3 – Leaf Length, 4 – Leaf Width, 5 – Fruit Length, 6 – Fruit Width, 7 – Fruit Wing Width, 8 – Flower Length, 9 – Branchlet Pubescence, 10 – Leaf Pubescence, 11 – Leaf Trichome Number, 12 – Fruit Pubescence

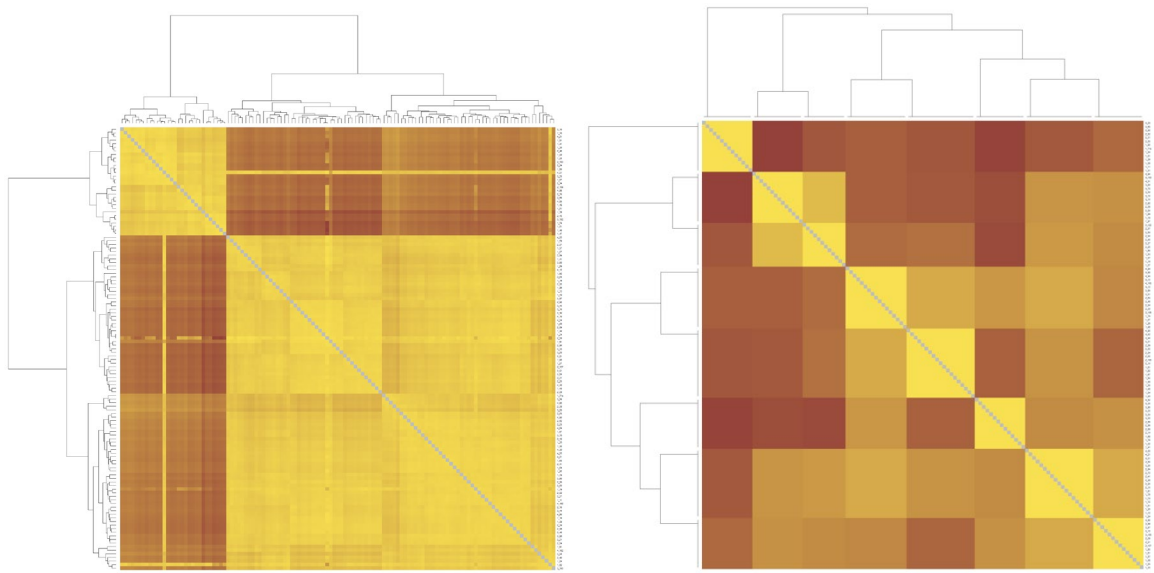
## F2 Morphometrics

Principal component analysis of the F2 population for all traits except flower color revealed two distinct groups of plants (Figure 3.5). Ellipses based on field row location show that rows one and two are clustered and rows three and four are clustered; however, all four row-based ellipses largely overlap. PC1 accounts for 20.4% of the observed variation and PC2 accounts for 13.7% of the observed variation.

Properly analyzing floral color is complex and it is important not to oversimplify the dataset. The F2 floral images revealed two to three distinct groups of color which roughly correlate with the floral colors of the F0 mother (*C. c. var. canadensis* ‘Appalachia Red’), the F0 father (*C. c. var. texensis* ‘Oklahoma’), and intermediate individuals (Figure 3.6A). Averaging the 9 pixel bins created in colordistance muddles the signal and is therefore inappropriate for this dataset (Figure 3.6B).



**Figure 3.5** PCA of F2 plants and F0 parents. Ellipses are colored by bins determined by leaf length (component 5). PC1 accounts for 20.4% of the observed variation while PC2 accounts for 13.7% of the variation. Component loadings shown as black arrows: 1 – Leaf Thickness, 2 – Leaf Sinus Shape, 3 – Leaf Apex Shape, 4 – Leaf Width, 5 – Leaf Length, 6 – Leaf Glossy, 7 – Flower Length, 8 – Fruit Length, 9 – Fruit Width, 10 – Fruit Wing Width, 11 – Branch Height, 12 – Tree Width, 13 – Tree Height.



**Figure 3.6** Pairwise comparisons of color distance of the F2 population. **A)** Plot based on 3x3 pixel bins. The resulting tree has three distinct clades likely representing individuals most similar to the F0 mother, F0 father, and intermediate individuals **B)** Plot based on the average of all pixel bins. For all plots, the yellower the comparison the more like the F0 father floral color (purple/magenta) F0 mother floral color (bright pink). The redder the comparison the more like the F0 mother floral color (bright pink).

Analysis of all red (R), green (G), and blue (B) colors in each image separately provided insight into what colors are most affecting the color distance matrix. A PCA followed by NMDS and pairwise distance comparisons confirmed that red has a unique influence on the distance matrix while blue and green have a similar effect (Figure 3.7). Individual pairwise distance comparisons for every accession provided lists of which accessions belonged to each clade of the distance tree. The component loadings of the PCA indicate that blue has the strongest effect on PC1 and little effect on PC2, while green and red also affect PC1 but have more effect on PC2 than blue. NMDS indicates that there are two distinct groups within the F2 comparisons based on the combination of R, G, and B.

**Figure 3.7A**

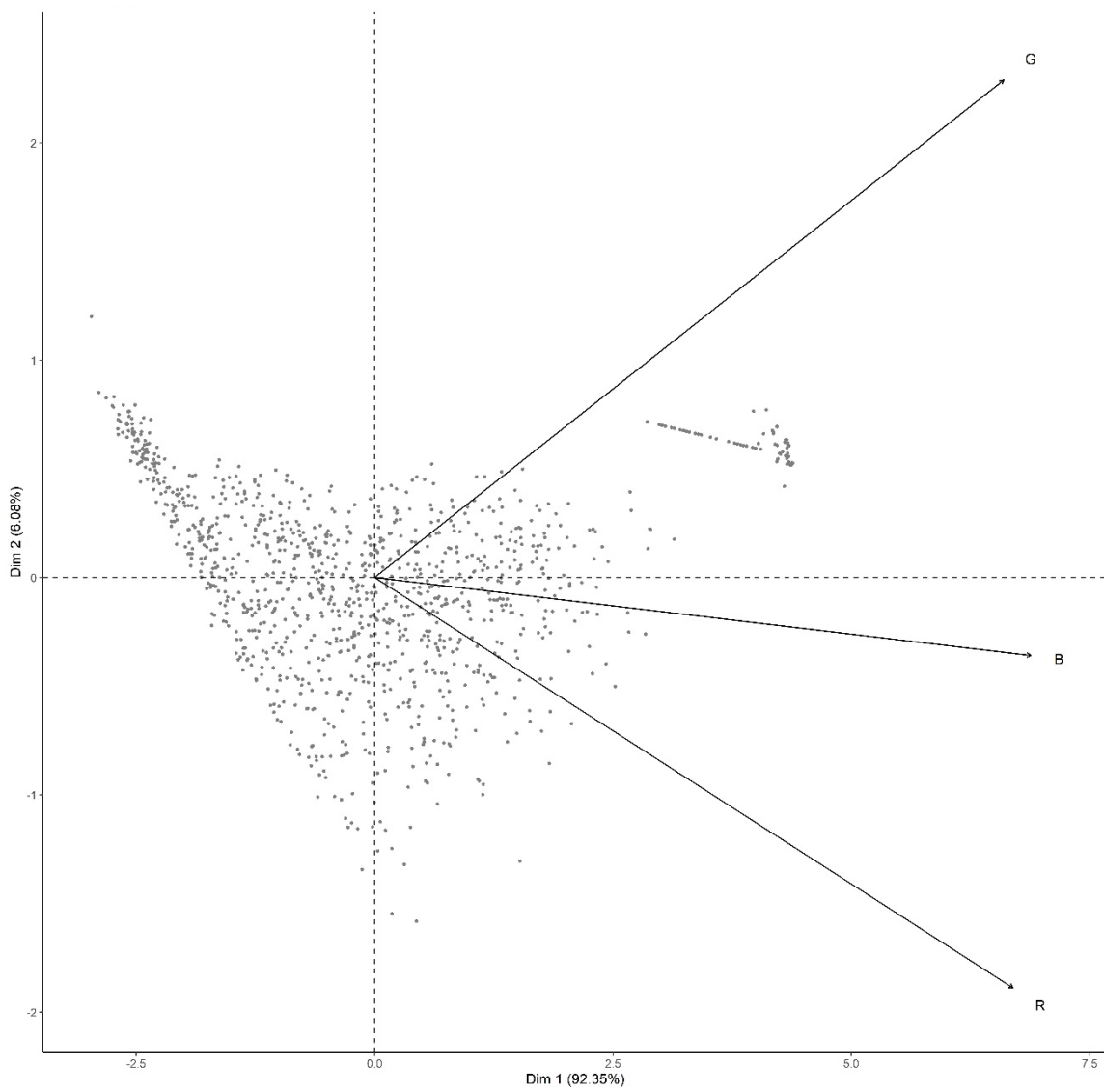


Figure 3.7B

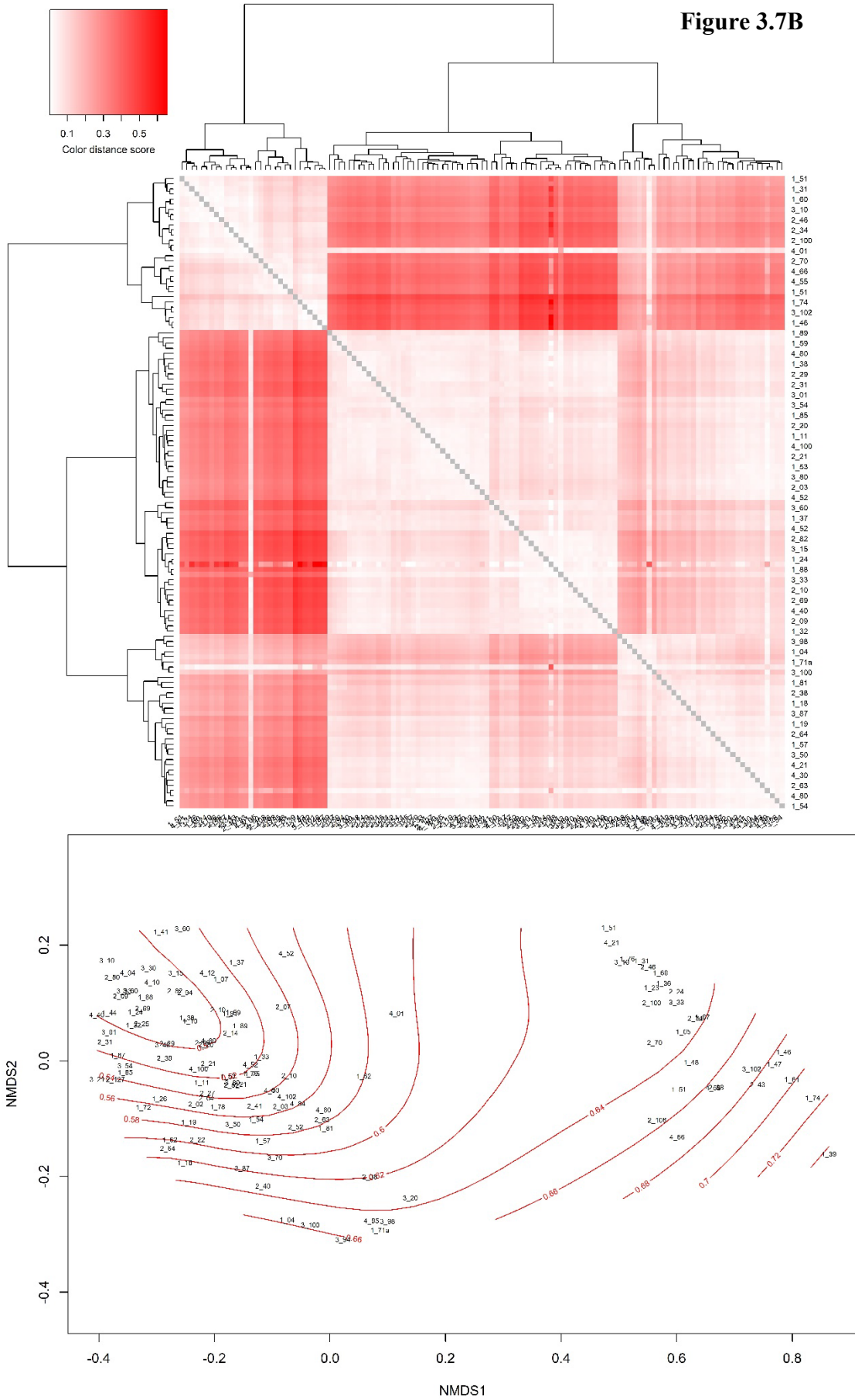


Figure 3.7C

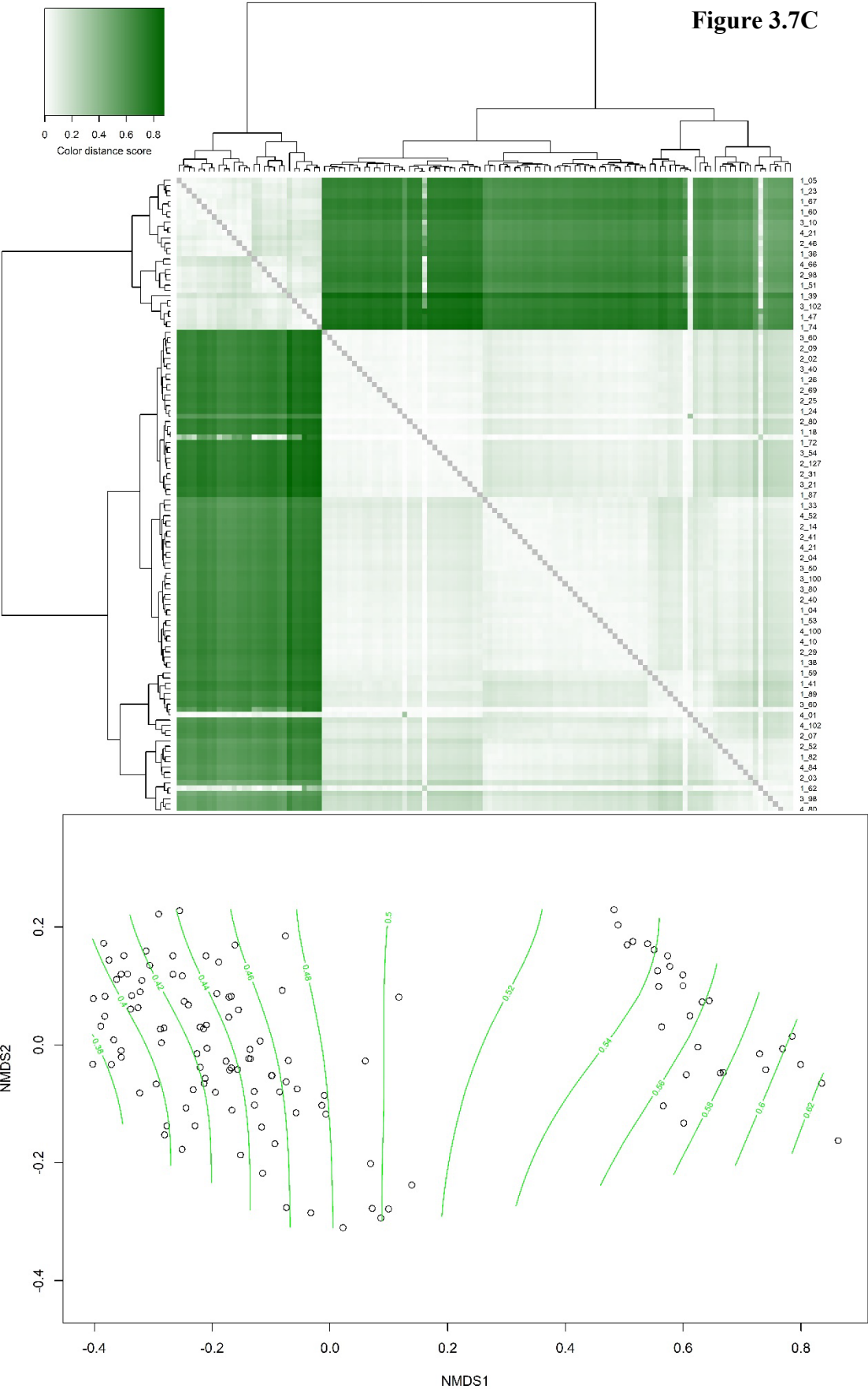
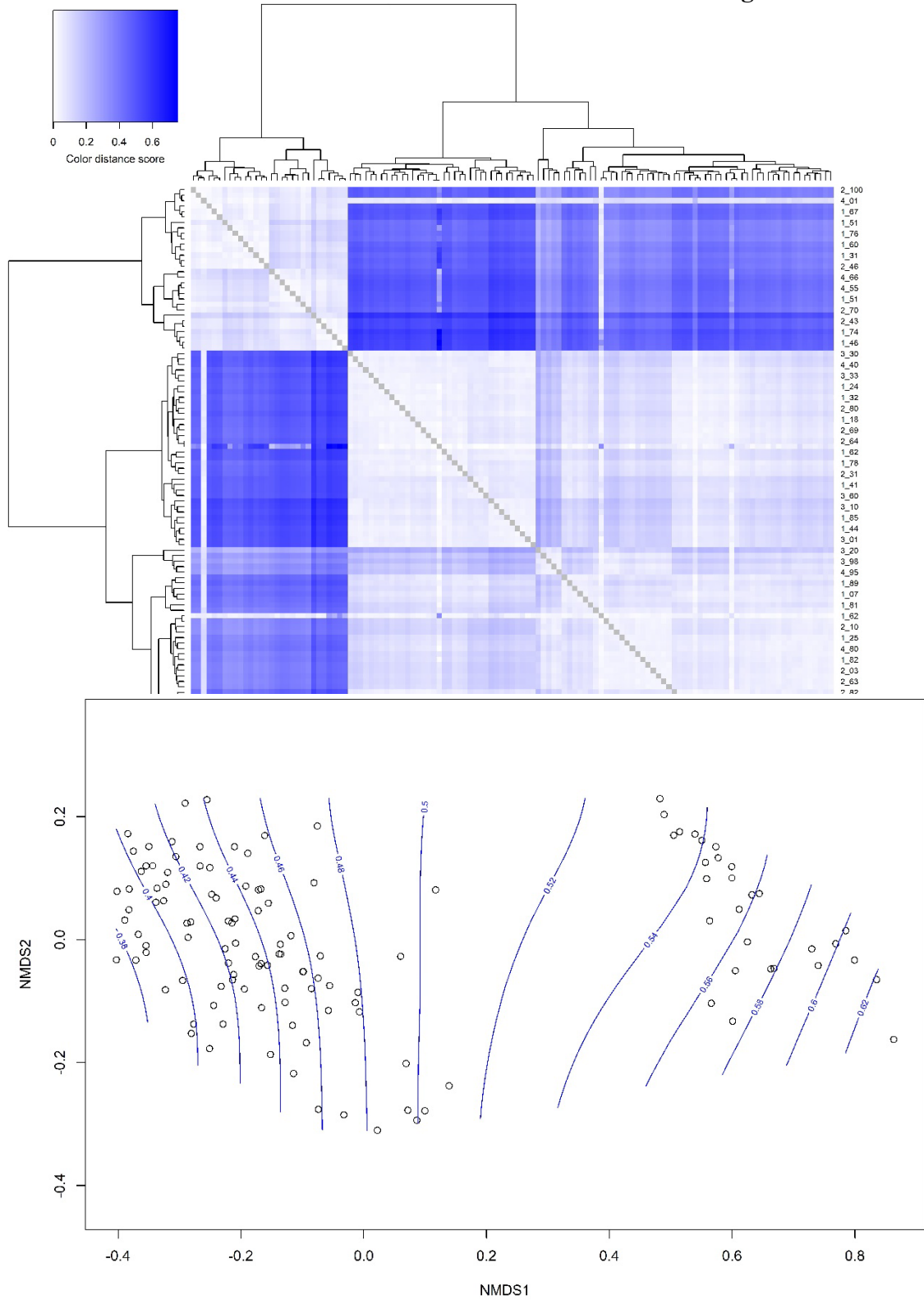
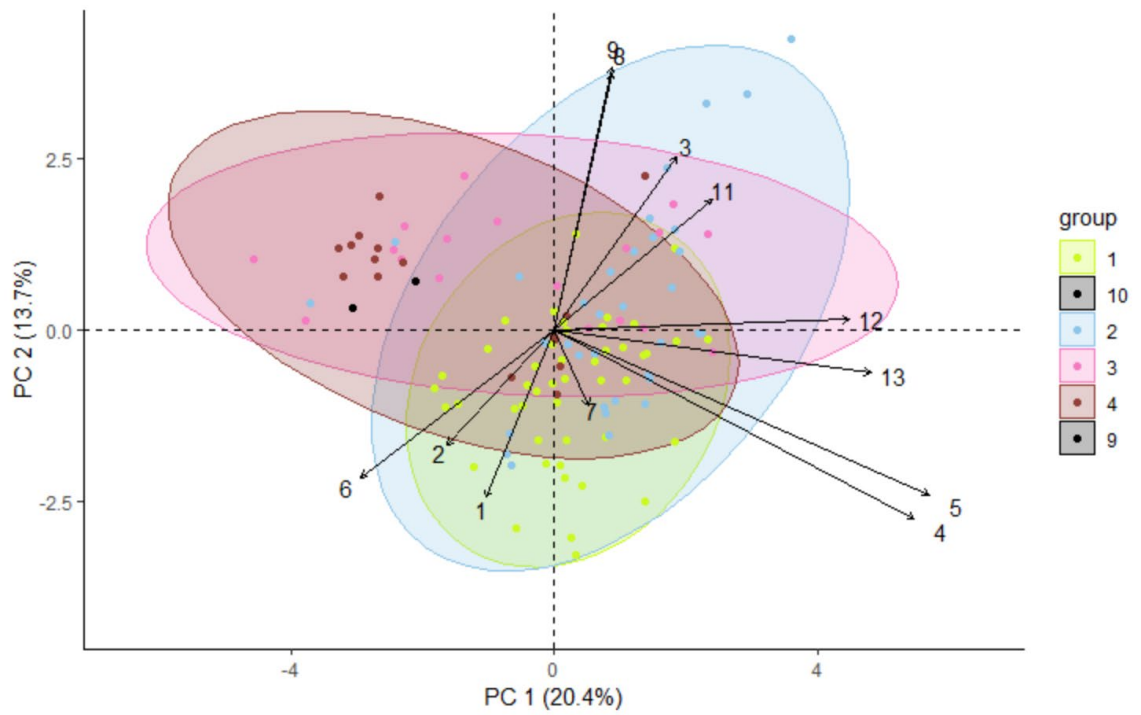


Figure 3.7D



**Figure 3.7** PCA, NMDS, and Pairwise Distance comparisons of RGB. **A)** PCA with component loadings as black arrows. Red denoted by R, blue denoted by B, and green denoted by G. Points are individual F2s with quantity of R,G, and B pixels determining placement **B)** Pairwise distance matrix and NMDS plot for all red (R) pixels **C)** Pairwise distance matrix and NMDS plot for all green (G) pixels **D)** Pairwise distance matrix and NMDS plot for all blue (B) pixels



**Figure 3.8** PCA of morphometric traits for all F2 individuals and both parents where ellipses are colored by the row in which the individual was planted. Both parents are represented by black dots and do not have ellipses.

## Discussion

### **Common Garden Cercis**

The *C. canadensis* var. *canadensis* collected in the JCRA common garden are morphometrically more similar to wild and cultivated *C. c.* var. *texensis* than wild *C. c.* var. *canadensis*. Points representing common garden *C. c.* var. *canadensis* (CGC, Figure 3.4) overlap broadly with Fritsch et al.'s wild sampled plants of *C. c.* var. *texensis* (TEX, Figure 3.4) and exhibit a significant shift in their morphological traits relative to their wild-collected counterparts (CAN, Figure 3.4). The environment of the JCRA may more closely mirror that of wild *C. c.* var. *texensis*. Analysis of temperature and precipitation data for the JCRA and the natural range of *C. c.* var. *texensis* is necessary to confirm this assertion. The genus *Cercis* is commonly found as understory vegetation so wild specimens are most likely to be found in part shade to full shade areas (Kidwell-Slak & Pooler, 2018). Trees grown at the JCRA are often exposed to fuller sun (unshaded) than naturally occurring trees. However, the JCRA is located within the range of *C. c.* var. *canadensis*, muddling the interpretation of these results (Figure 1.2; Fritsch et al., 2009). Comparison between common garden plants, piedmont region of North Carolina plants, and source regions for common garden plants could provide additional insights into these results. It is also worth noting that an increased number of samples grown in a common garden would greatly increase the power of this analysis to detect the effect of environment on morphological characters. Despite JCRA being the home of the national collection of *Cercis*, the collection is limited to a total of 13 accessions of *Cercis canadensis* with known provenance.

## F2 Cercis Breeding Population

All analyses of the F2 population revealed two distinct groups of plants. These groups roughly correlate with the traits historically associated with *Cercis canadensis* var. *texensis* and *Cercis canadensis* var. *canadensis*. The group most morphologically similar to *C. c.* var. *canadensis* contains more individuals than the group most similar to *C. c.* var. *texensis*, this is likely because heterozygous plants appear more similar to *C. c.* var. *canadensis* than to *C. c.* var. *texensis*. The F0 parents of this F2 breeding population were selected because of the extremities of their morphological variation (Table 3.3). The seed parent has longer, narrower, and thinner leaves with a glabrous surface; larger flowers; longer fruit but with a smaller width wing; and the architecture of the tree is shorter and wider with branching beginning closer to the ground (overall spreading habit). The pollen parent has shorter, wider, and thicker leaves with a glossy leaf surface; smaller flowers; shorter fruit with a larger wing width; and the tree is taller and narrower with branching beginning higher up on the trunk (overall upright or vasiform habit).

**Table 3.3** Comparison of traits measured for the F0 mother and father of the F2 population

<b>Trait</b>	<b><i>C. c. var. canadensis</i> 'Appalachia Red'</b>	<b><i>C. c. var. texensis</i> 'Oklahoma'</b>	<b>F2 Plants (Average±StDev)</b>
<b>Leaf Length</b>	91.0971	81.3689	69.822±31.029
<b>Leaf Width</b>	87.8078	103.9876	83.098±36.864
<b>Leaf Thickness</b>	0.2468	0.3166	0.269±0.027
<b>Leaf Apex Shape</b>	3	3	3.076±0.73
<b>Leaf Sinus Shape</b>	4	5	4.067±.8
<b>Leaf Glossiness</b>	0	1	0.211±0.409
<b>Flower Length</b>	13.0556	10.9728	12.008±0.823
<b>Flower Color</b>	Bright Pink	Purple/Magenta	Various
<b>Fruit Length</b>	67.9323	57.6707	62.809±9.308
<b>Fruit Width</b>	13.1191	12.6873	12.277±1.078
<b>Fruit Wing Width</b>	1.7272	2.6289	1.633±0.362
<b>Tree Height</b>	127.7754	161.7299	1702.999±429.81
<b>Tree Width</b>	209.4184	199.86628	1346.943±375.054
<b>Branching Height</b>	18.7784	36.73408	304.935±156.647

The pattern of plants in rows 1 and 2 being primarily spread along PC1 while plants in rows 3 and 4 were mostly spread along PC2 is unlikely explained by environmental factors such as light or water availability. There is broad overlap between ellipses containing all four rows of plants (Figure 3.8). All individuals were evenly spaced upon initial planting, the field is irrigated by an automated watering system, and the field is generally level (no row is at a higher elevation than another). Fields at the SRS are also consistently treated with a well-established integrated pest management plan so fungal, bacterial, or pest related diseases are rare. Last, the rows containing the F2 population are in full sun which may be more similar to the environment of *C. c. var. texensis* than *C. c. var. canadensis* despite being in the latter's natural range.

### **Conclusion**

Together, the results from the common garden and F2 populations indicate that despite environment, there is likely sufficient morphological evidence to segregate *Cercis canadensis var. texensis* from *Cercis canadensis var. canadensis* at a subspecific level. Because of their ability (geographic overlap) and tendency for hybridization (outcrossing) in the wild, the identity of naturally occurring plants may be difficult to distinguish based on morphology alone making these taxa most equivalent to Clausen et al.'s ecospecies with multiple ecotypes rather than as distinct species (Clausen et al., 1939). The common garden dataset combined with Fritsch et al.'s environment contrasts on leaf adaptations implies that environment plays a role in observed morphological variation. To reach a pluralistic taxonomic consensus for these taxa, the inclusion of genomic, reproductive biological, geographic, and additional ecological data is necessary. Expanding on this approach through morphometric and genomic analyses within and between natural populations at the

geographic extremes and in the center of the hybrid zone (Kansas, Missouri, Oklahoma, Arkansas, Louisiana, eastern Texas) of these two taxa would be a logical next step in this research (Figure 1.2).

## **Supplementary Materials**

### **S.1 Taxonomic History of the genus *Cercis* (Fabaceae)**

For a taxonomic name to be accepted it must be validly and legitimately published. The definitions of valid and legitimate are very nuanced but a brief explanation is that a name has a botanical authority (author), diagnosis/description and type specimen including where it is housed associated with the name. It also must be published in a journal with an isbn number. Without these things it is not considered valid or legitimate.

#### **North American *Cercis***

1753 - *Cercis canadensis* validly and legitimately described as a *sp. nov.* by Carolus Linnaeus in the *Species Plantarum* (p. 374). This description is based upon plants grown from seed purportedly from Canada or Virginia and were described as having “pubescent leaves”

1813 – *Cercis canadensis* var. *pubescens* validly and legitimately described by Frederick Traugott Pursh in *Flora Americae Septentrionalis*.

1850 – *Cercis occidentalis* is legitimately published by John Torrey but later validly published by Asa Gray in the *Boston Journal of Natural History* 6(2): 177-178.

Translation of original description: a shrub, having subreniform to obtuse leaves and oblong to obtuse, short, apiculate, and scarcely stipitate fruit.

1850 – *Cercis reniformis* is published as a *nomen nudum* by George Engelmann and then placed into synonymy of *C. occidentalis* by Asa Gray in the *Boston Journal of Natural History* 6(2): 177.

1857 – *Cercis californica* is illegitimately published by John Torrey but later validly published by George Bentham in *Plantas Hartwegianas imprimis Mexicanas* [307], 361 for “having distinct pods”.

1878 – *Cercis occidentalis* var. *texensis* validly and legitimately published by Sereno Watson in *Smithsonian Miscellaneous Collections* 258: 209. Synonymous with *C. c.* var. *texensis* (S. Watson) M. Hopkins, *C. c.* subsp. *texensis* (S. Watson) A.E. Murray, and *C. texensis* (S. Watson) Sarg.

1891 – *Cercis texensis* published as a *combinatio nova* by Charles Sprague Sargent in *Garden & Forest* 4: 778 using *Cercis occidentalis* var. *texensis* S. Watson as the basionym.

1897 – *Cercis canadensis* var. *plena* published by George Bishop Sudworth in the *Division of Forestry of the United States Department of Agriculture Bulletin* 14: 253. This name is based on a cultivated specimen originally grown at Kew Gardens and is meant to encompass double flowered forms of *Cercis canadensis* but was observed in the wild somewhere on the shores of the Mississippi River historically. This name is best dropped to a form and named as a cultivar group under rules of horticultural nomenclature.

1907 – *Cercis canadensis* fo. *alba* published by Alfred Rehder in *Mitteilungen der Deutschen Dendrologischen Gesellschaft* 1907: 72. This name is for the white flowered form of *Cercis canadensis*

1912 – Edward Lee Greene describes seven new *Cercis* species as *sp. nov.* in *Repertorium Specierum Novarum Regni Vegetabilis* 11(274/278): 110–111, all of which have fallen into synonymy of *C. canadensis* or *C. occidentalis* except *C. orbiculata*. This treatment includes *C. orbiculata*, *C. nitida*, *C. nephrophylla*, *C. dilatata*, *C. ellipsoidea*, *C. georgiana*, and *C. latissimi*. These taxa were a split of North American *Cercis* into multiple species based on slight morphological differences, geographic location, and habitat.

1914 – *Cercis canadensis* var. *alba* published as a *combinatio nova* by William Jackson Bean in *Trees and Shrubs Hardy in the British Isles* 1: 334. Original basionym *C. c.* fo. *alba* Rehder

1926 – *Cercis spokaneensis* published by Knowlton in *Department of the Interior, United States Geological Survey, Professional Paper* 140: 43, pl. 29, f. 9. This name is for a fossil record not an extant taxon.

1930 – *Cercis mexicana* published by Joseph Nelson Rose in the *North American Flora* 23(4): 202. Synonymous with *C. c.* var. *mexicana* (Rose) M. Hopkins and *C. c.* subsp. *mexicana* (Rose) A.E. Murray

1932 – *Cercis arizonica* invalidly published as a *nomen nudum* without an author citation in *Department of the Interior of the United States National Park Service Technical Bulletin* 6: 23. Then published again without a Latin diagnosis

1936 – *Cercis arizonica* published without a Latin diagnosis by N. N. Dodge and attributing the original description from 1932 to Rose in the *Natural History Bulletin of the Grand Canyon National History Association* 3: 56. Now considered an invalid synonym of *C. c.* var. *orbiculata* (Greene) Barneby and *C. occidentalis* Torr. ex A. Gray

1936 – *Cercis canadensis* fo. *glabrifolia* publish by Merritt Lyndon Fernald in *Rhodora* 38(450): 234. No Fascinating read on taxonomic arguments.

1941 – *Cercis occidentalis* var. *orbiculata* validly and legitimately published by Ivar (Frederick) Tidestrom in *A Flora of Arizona and New Mexico*, 155, with *Cercis orbiculata* Greene as the basionym.

1942 – Milton Hopkins publishes a taxonomic treatment for *Cercis canadensis* naming multiple var. nov. in *Rhodora* 44(522): 208.

*Cercis canadensis* var. *mexicana* is validly and legitimately published using *C. c.* subsp. *mexicana* (Rose) A.E. Murray as the basionym

*Cercis canadensis* var. *typica* is illegitimately published as the “typical” form of *Cercis canadensis* making it a synonym of *Cercis canadensis* var. *canadensis*

*Cercis canadensis* var. *texensis* is validly and legitimately published as a combinatio nova using *Cercis occidentalis* var. *texensis* S. Watson as the basionym. Synonymous with *Cercis reniformis* Engelm. ex A. Gray

1982 – Albert Edward Murray published two new *combinatio novum* in *Kalmia* 12: 19

*Cercis canadensis* subsp. *mexicana* is validly and legitimately published using *Cercis mexicana* Rose as the basionym.

*Cercis canadensis* subsp. *texensis* is validly and legitimately published using *Cercis occidentalis* var. *texensis* S. Watson as the basionym

1989 – *Cercis canadensis* var. *orbiculata* is validly and legitimately published by Ruper Charles Barneby in *Intermountain Flora* 3(B): 9. Using *Cercis orbiculata* Greene as the basionym. This is synonymous with *C. occidentalis* var. *orbiculata* (Greene) Tidestr., *C. arizonica* Rose ex N.N. Dodge, and *C. orbiculata* Greene.

### European *Cercis*

1753 - *Cercis siliquastrum* validly and legitimately described as a *sp. nov.* by Carolus Linnaeus in the *Species Plantarum* (p. 374)

1880 – *Cercis siliquosa* invalidly published by Jean Baptiste Saint-Lager in *Annales de la Société Botanique de Lyon* 7: 122. This publication seems to be a misspelling of *Cercis siliquastrum* as the author specifically refers to “*C. siliquosa*” as being described by Linnaeus. This should be dropped into synonymy with *C. siliquastrum*

1917 – *Cercis siliquastrum* var. *hebecarpa* published by Joseph Friedrich Nicolaus Bornmuller in *Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem* 7: 15. Name based on having velutinous fruit.

1967 – *Cercis siliquastrum* subsp. *hebecarpa* published as a *subsp. nov.* by Faik Yaltirik in *Notes from the Royal Botanic Garden, Edinburgh* 28: 13.

1972 – *Cercis hebecarpa* is published as a *combinatio nova* by Jiri Ponert in *Feddes Repertorium* 83(9–10): 618 using *Cercis siliquastrum* var. *hebecarpa* Bornm. as the basionym.

### Asian *Cercis*

1835 – *Cercis chinensis* published as an annotation (translation from *Enum. Pl. Chn. Bor.* 21, 1833) by Alexander Andrejewitsch Bunge in *Mémoires Presentes a l'Académie Impériale des Sciences de St.-Pétersbourg par Divers Savans et lus dans ses Assemblées* 2: 95.

1852-1853 – *Cercis japonica* published legitimately but invalidly by Jules Emile Planchon then published validly by Philipp Franz (Balthasar) von Siebold in *Flore des Serres et des Jardins de l'Europe* 8: 269.

1872 – *Cercis griffithii* validly and legitimately published by Pierre Edmond Boissier in *Flora Orientalis* 2: 633.

1889 – *Cercis racemosa* published as a *sp. nov.* by Oliver Daniel in Hooker's *Icones Plantarum* 19(4).

1910 – *Cercis glabra* published by Renato Pampanini in *Nuovo Giornale Botanico Italiano, Nuova Serie* 17(3): 393–394, f. 9. Synonymous with *C. funiushanensis* S.Y. Wange & T.B. Chao, *C. pubescens* S.Y. Wang, and *C. yunnanensis* Hu & Cheng.

1927 – *Cercis chingii* published as a *sp. nov.* by Woon Young Chun in *Journal of the Arnold Arboretum* 8(1): 20-21.

1937 – *Cercis likiangensis* published illegitimately by Chun ex Y. Chen in the *Flora of China*. Synonymous with *Cercis chuniana*

1940 – *Cercis chuniana* published validly and legitimately by Franklin Post Metcalf in *Lingnan Science Journal* 19(4): 551–552, f. 2.

1944 – *Cercis pauciflora* published validly and legitimately by Hui Lin Li in *Bulletin of the Torrey Botanical Club* 71(4): 425. Later placed into synonymy with *Cercis chinensis* Bunge

1948 – *Cercis yunnanensis* is validly and legitimately published by Hu & Cheng in *Bulletin of the Fan Memorial Institute of Biology*, new series 1: 193. Later placed into synonymy with *Cercis glabra* Pamp.

1966 – *Cercis chinensis* fo. *rosea* is validly and legitimately published by Ping Sheng Hsu in *Acta Phytotaxonomica Sinica* 11(2): 193. Named from a cultivated specimen for having rosy-pink flowers and blooming a little earlier than typical *C. chinensis*.

1966 – *Cercis chinensis* fo. *alba* validly and legitimately published by Shi Chang Hsu in *Acta Phytotaxonomica Sinica* 11(2): 193. Named from a cultivated specimen for having white flowers.

1977 – *Cercis chinensis* fo. *leucantha* published by Junichi Sugimoto in *Journal of Geobotany* 24(3): 62. This is a white flowered form of *Cercis chinensis*

1980 – *Cercis funiushanensis* published by Sui Yi Wang and Tien-bang Chao in the *Journal of Henan Agricultural Coll.* 2: 8. Now a synonym of *Cercis glabra* Pamp.

1980 – *Cercis pubescens* published by Sui Yi Wang in the *Journal of Henan Agricultural Coll.* 2: 8. Now a synonym of *Cercis glabra* Pamp.

1983 – *Cercis chinensis* fo. *pubescens* is published by Chao Fen Wei in *Guihaia* 3(1): 15.

1993 – *Cercis gigantea* is illegitimately and invalidly published (no type or description or diagnosis provided) by Wan-chun Cheng and Pai Chieh Keng in *Flora of Zhejiang* 3: 279.

#### **Ambiguous or Illegitimate *Cercis* taxa**

1783 – *Cercis pumila* published as a *nomen nudum* by W. Young in *Cat. Arbres, Arbustes & Pl. Herb. Am.* 6 (the author and source of this journal are still under investigation and should be considered a best guess without further information)

1796 – *Cercis florida* published as a *nomen nudum* by Richard Anthony (nee Markham) Salisbury in *Prodromus stirplum in horto ad Chapel Allerton vigentium*.

## CHAPTER 4

### IDENTIFICATION OF QUANTITATIVE TRAIT LOCI IN *CERCIS CANADENSIS* L.

#### **Introduction**

Integration of morphometrics and genomics through the identification of genetic loci underlying phenotypic traits, also known as quantitative trait loci (QTL) mapping, is one of multiple ways to address modern taxonomic delimitation issues. Possible approaches include QTL mapping in an F2 population, genome wide association studies (GWAS), and coalescence-based species delimitation (Lander & Botstein, 1989; Risch & Merikangas, 1996; Sukumaran et al., 2021). QTL mapping and GWAS investigations of the genetic basis of variation in the traits measured in chapter 3 (Table 3.3) can inform taxon delimitation in *Cercis canadensis*. In this chapter I ask if it is possible to reconcile the findings of chapter 3 (that phenotype suggests infraspecific ranking is appropriate for the proposed taxa) with the portions of the genome associated with those traits.

Traditional genome-enabled QTL studies involve generating genome data for the F0 parents, calling Single Nucleotide Polymorphisms (SNPs) for each parent, identifying the loci that differ between them, mapping reads from the F2s to the parental consensus sequence, calling SNPs for the F2s, and statistically linking the F2 SNP genotypes with measured morphological traits (Risch & Merikangas, 1996). It is worth noting that traditional QTL approaches have typically required deep sequencing at loci of interest to distinguish homozygous from heterozygous genotypes. This has been done by utilizing reduced representation sequencing such as RadSeq and Genotyping by Sequencing (GBS).

Both GBS and RadSeq enrich for sequence reads mapping select portions of the genome flanked by particular restriction enzymes. By limiting sequencing to DNA fragments cut by the restriction enzyme deep sequencing coverage can be obtained more readily than with whole genome shotgun sequencing (Elshire et al., 2011; Peterson et al., 2012). Statistical power for identifying loci linked to measured traits increases with the number of genotyped F2 individuals. By comparison, GWAS does not necessitate controlled crossing of known parental genotypes, nor a breeding population (e.g F2 population). However, unlike QTL approaches, GWAS must correct for genotypic associations attributable to population structure or kinship. Relatedness can be factored as a covariate before assessment of SNP genotype-phenotype associations (Liu et al., 2016; Uffelmann et al., 2021). Similar to bulk segregant analyses, the QTL mapping analysis pipeline Khufu (Korani et al., 2021) uses low coverage sequence data derived from individuals in an F2 population by clustering individuals into bins based on measured trait values. By binning individuals with similar traits values, low coverage for sequence data can assess associations between trait states and SNPs associated with the observed trait variation (Korani et al., 2021) without assessing heterozygosity/homozygosity at each SNP locus for each individual in an F2 population.

Unlike QTL mapping approaches using progeny arrays (such as F2 populations), GWAS approaches statistically control for the influence of kinship or population structure on phenotypic similarity as a covariate. Rather than using an F2 population, GWAS identifies markers that covary with phenotypic variation while accounting for the degree of kinship or genome-wide relatedness. GWAS estimation programs such as FarmCPU (Liu et al., 2016) use SNP calls at each locus. Missing data and

heterozygosity/homozygosity can be imputed using programs such as STITCH (Davies et al., 2016). Ultimately, both QTL and GWAS analyses enable the identification of genomic segments that include genes that are at least partially responsible for observed variation in phenotypic traits, and thus enable downstream analyses for pluralistic taxonomic delimitation.

## **Methods**

### **Development of the F2 Breeding Population**

The F2 breeding population was developed by Dr. Dennis Werner at North Carolina State University (NCSU). He crossed *C. c. var. canadensis* ‘Appalachia Red’ (F0 mother) with *C. c. var. texensis* ‘Oklahoma’ (F0 father). In spring 2018, two F1 trees moved from the common garden at the Sandhills Research Station (SRS), potted in 15-gallon containers, and intermated in the greenhouses at NCSU. Flowers receiving pollen were emasculated using forceps and a paintbrush was used to apply pollen from donor flowers. The seed from these 2 F1 trees was bulked, and 692 viable plants were obtained after germination in winter, 2019. These seedlings were transplanted to a field nursery at the JC Raulston Arboretum in spring 2019, and ultimately transplanted to the field plot at the SRS in early winter 2020. Additional seed was collected in September 2018 from 3 different open-pollinated F1 trees in the SRS field and were combined with the controlled crosses for germination and planting in a common field at SRS. There are multiple fields at the SRS with dozens of horticultural crosses of *Cercis canadensis* that could have served as pollen parents for seed set the open-pollinated F1 seed-parents. Dr. Werner is certain that “very few of these F2 seedlings derived from open pollinated F1 parents made it to the field.” Saplings from the complex F2 population were planted exactly four feet apart in

each row which are spaced twelve feet apart. After a full season of growth and acclimatization to the SRS fields, immature leaf and stem tissue was sampled for DNA extraction. Additional tissue was collected for DNA extraction from swollen buds while the plants were dormant between the fourth and fifth growing season.

### **DNA Extraction & Library Preparation**

Tissue was harvested from all trees sampled for the morphometric study including the F0 parents of the F2 population. Samples were immediately stored on liquid nitrogen until being transferred to a -80°C freezer. Tissue (1.5g) of each accession was ground to a fine powder using two, 2.8mm ceramic beads (Omni International) and one steel 4.4mm bead in a 2mL thick-walled tube in a Genogrinder Bead Mill running at 1500rpm for 3 rounds of 2 minutes each. DNA was then extracted from the powdered tissue using a modified CTAB protocol (Porebski et al., 1997). Samples were then cleaned using New England Biolabs Monarch® PCR & DNA cleanup kit (T1030S) and eluted into 50uL of molecular grade water. Concentration of each sample was then quantified using a Qubit 2.0 fluorometer. Samples containing less than 30ng/uL of DNA in 50uL were combined with additional rounds of DNA extraction and then concentrated in a speedvac until they reached a volume of 50uL. Samples were then stored in a -20°C freezer until being used for DNA library preparation.

Library preparation was completed using the KAPA Hyperplus Kit (KK8514) with initial DNA volume input calculated using Qubit scores, a five-minute fragmentation time, 12 to 16 hours of adapter ligation including i5 and i7 barcodes at 4°C, and six rounds of library amplification. The quality of the resulting libraries was then quantified via Agilent Bioanalyzer high sensitivity chip and qPCR. Libraries with two nanomolar concentration

and above were then pooled by the Georgia Genomic and Bioinformatics Core before being sent to Hudson Alpha for whole genome shotgun sequencing with Illumina NovaSeq technology. F2s were sequenced to a depth of 5x coverage and the F0 parents were sequenced to a depth of 30x coverage.

### **Bioinformatics**

Raw reads were trimmed using Trimmomatic and mapped to an available *Cercis canadensis* reference genome developed by the Open Green Genomes project (<https://phytozome-next.jgi.doe.gov/ogg/>) using BWA (Bolger et al., 2014; Li & Durbin, 2009). Single Nucleotide Polymorphisms (SNPs) were then called and analyzed using the Khufu pipeline (Korani et al., 2021) for QTL mapping analysis, and SNITCH (Davies et al., 2016) followed by filtering for imputation of genotypes (AA, AB or BB) at each SNP locus for GWAS analysis. Khufu is conceptually related to SWEEP (Clevenger & Ozias-Akins, 2015; pers. comm., Josh Clevenger, 2022), software used to identify homoeologous sequences within tetraploid peanut lines with low coverage sequence data.

The Khufu analysis failed to identify QTL due to an unexpectedly high number of alleles for each SNP locus. This could be because the parental genotypes were highly heterozygous and an unknown fraction of the “F2” seed was derived from open pollination of the F1 trees. Therefore, FarmCPU (Liu et al., 2016) was used for a GWAS analysis. FarmCPU is unique in that it iteratively applies a fixed effect model (FEM) and a random effect model (REM) of associations between phenotypic measurements and genotypes at SNP loci. The FEM estimates associations one SNP locus at a time, treating closely linked SNP loci as covariants. To minimize model overfitting, a common problem in GWAS, the random-effect model estimates pseudo covariate markers to define kinship within the

population. Finally, the p-values of the fixed and random effects models are unified at the end of each iteration controlling for overfitting of the model. P-values were corrected for multiple tests using Bonferroni correction which is often considered too conservative for identifying meaningful associations in GWAS analyses.

Manhattan plots for each trait were created for each trait with chromosome position on the X-axis and corrected p-values on the Y-axis (figure 4.1). A PCA of the SNPs called for the “F2 population” was also created with PC1 and PC2 accounting for 11.87% and 3.99% of the observed variation respectively (figure 4.2).

### **Results**

An average of 12,475,832 reads were generated for each F2 individual (Standard deviation=5,270,020). After quality trimming, an average of 89.7% of those trimmed reads mapped to the reference genome for all F2 individuals (Table 4.1).

The FarmCPU (Liu et al., 2016) GWAS analysis included 223,443 SNPs called across the entire F2 population. Of these, 5,607 were inferred as significantly linked to the measured traits ( $p < 0.05$ ) after being adjusted with Bonferroni. Bins of SNPs for each trait were visually identified using the manhattan plots. Leaf thickness contains bins of SNPs on all seven chromosomes. Leaf sinus shape has a much weaker signal but still has visible bins on chromosome 3 and 4. Leaf apex shape has a strong signal for bins on chromosomes 1, 2, 4, and 5. Leaf width has a very weak signal but hints of peaks on chromosomes 4, 5, and 7. Leaf length has a weak signal but evidence of peaks on chromosomes 3 and 4. Leaf glossiness has a moderate signal and evidence of peaks on chromosome 1, 2, 4, and 7. Flower length has peaks present on all chromosomes. Fruit length has no clearly distinct peaks across any of the chromosomes. Fruit Width has clear peaks on chromosomes 4, 5,

6, and 7. Tree Width has peaks on chromosomes 2 and 3 and tree height has peaks on chromosomes 3, 5, and 6. Branching Height has clear peaks on chromosomes 4 and 5. The regions of the genome under these peaks are candidates for future work in both breeding efforts and taxonomic delimitation within the genus *Cercis*.

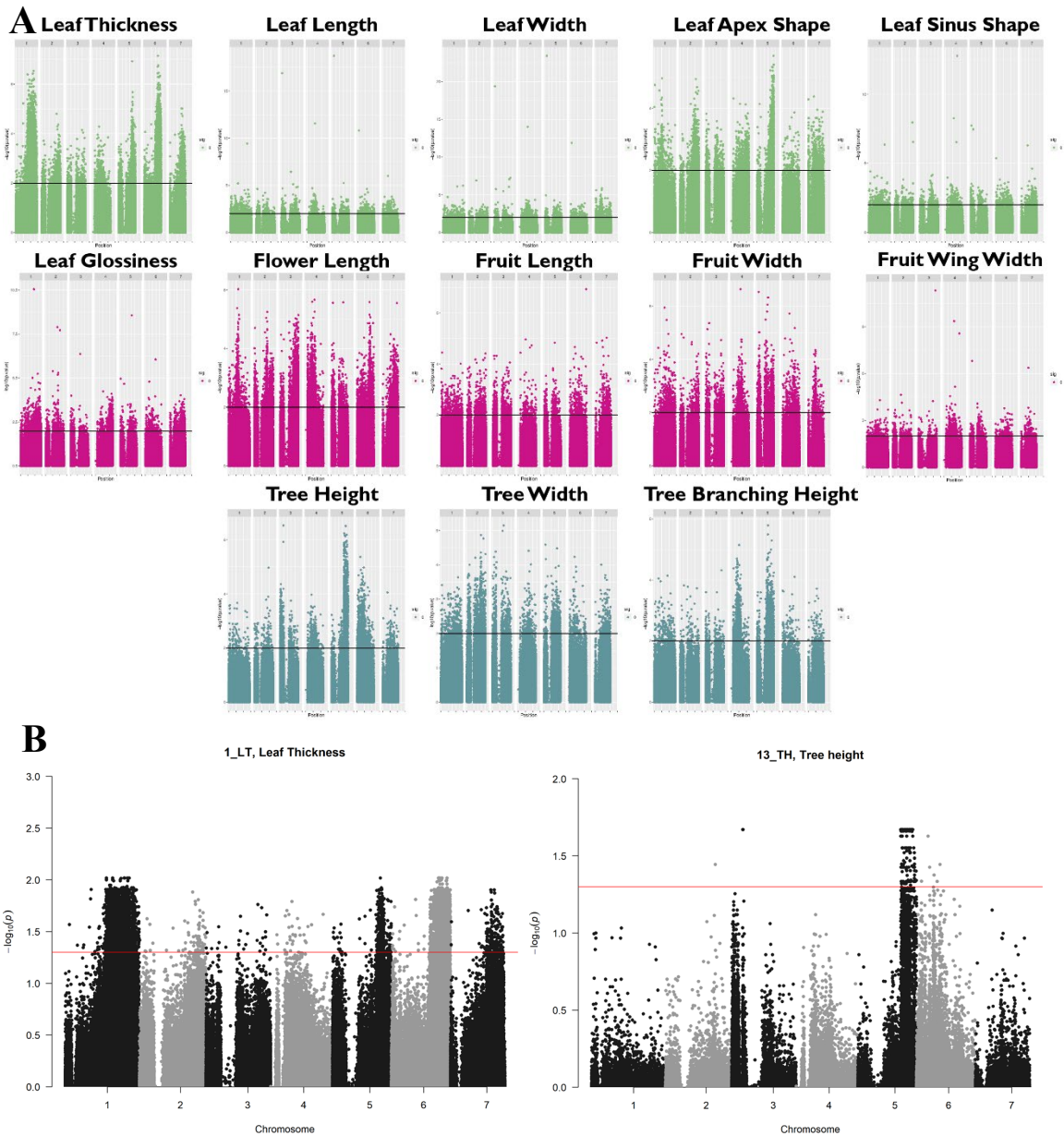
**Table 4.1** Summary of DNA sequencing reads for each F2 individual

<b>Sample ID</b>	<b># of reads (raw)</b>	<b># of reads (cleaned)</b>	<b># of reads (mapped)</b>	<b>% reads mapped</b>
1_4	9059000	5997908	5485437	91.46
1_5	10864576	8001569	7191086	89.87
1_7	578160	448097	406655	90.75
1_10	7934590	5993504	5576837	93.05
1_11	16882972	13072867	11908694	91.09
1_18	9119972	7119103	6446212	90.55
1_19	12085328	9546793	8694570	91.07
1_23	10560292	8131934	7319261	90.01
1_24	10394874	7876918	7176907	91.11
1_25	13289680	9540637	8711795	91.31
1_26	9010400	5902724	5430812	92.01
1_31	12306576	9110818	7912866	86.85
1_32	13073302	10025922	9196571	91.73
1_33	15256356	10238738	9142716	89.30
1_37	10833240	9103730	8397975	92.25
1_38	3105548	2358613	1929367	81.80
1_39	19855290	13744065	12130693	88.26
1_41	14733836	10441580	9715523	93.05
1_44	10262562	8740346	7579625	86.72
1_46	435854	329194	298673	90.73
1_47	10545502	8375414	7756055	92.61
1_48	24525154	18582366	16294956	87.69
1_51	17610712	5967880	5099496	85.45
1_53	10200962	7852098	7242999	92.24
1_54	8962836	6929507	6372029	91.96
1_57	18156506	12153922	10778315	88.68
1_59	21057560	16570941	14979147	90.39
1_60	10453310	8017792	6757744	84.28
1_61	12109224	9112326	8411294	92.31
1_62	11999092	9581712	8776050	91.59

1_67	11027022	9213150	7853675	85.24
1_71a	12235206	9501885	8420351	88.62
1_72	25853956	18957859	16965198	89.49
1_74	11023796	8666110	7919234	91.38
1_76	10058004	7902234	7077214	89.56
1_78	9586124	7436956	6772248	91.06
1_79	10023676	7970734	7261210	91.10
1_81	18416974	14980853	13077125	87.29
1_82	10118326	8112228	7519152	92.69
1_85	6891074	5270364	4480801	85.02
1_87	18947112	15810726	13517584	85.50
1_88	16501944	13071914	11404086	87.24
1_89	12767480	10016654	8821132	88.06
1_91	12924226	9021595	8267490	91.64
1_92	18931142	13599404	12273994	90.25
2_2	10966450	8988298	8031052	89.35
2_3	11036644	7857475	6957129	88.54
2_4	14609226	10904953	9877976	90.58
2_7	1138	835	728	87.19
2_9	14414560	11767979	10800958	91.78
2_100	14203298	9680849	8915106	92.09
2_108	12267824	9309436	8359352	89.79
2_10	8621272	6874875	6025957	87.65
2_127	10156720	7384841	6570457	88.97
2_14	10648678	9226533	8254443	89.46
2_20	13441618	10414097	9613452	92.31
2_21	6487572	4086286	3430132	83.94
2_22	20977118	15711854	14024594	89.26
2_24	25046076	16957064	14686223	86.61
2_25	11984428	10074933	8810775	87.45
2_27	596610	467672	424186	90.70
2_29	9026632	6987745	5847533	83.68
2_31	9091292	7447362	6705302	90.04
2_34	12702014	10233170	9243244	90.33
2_38	11087464	8730351	7803538	89.38
2_39	14810680	11852971	10334625	87.19
2_40	8456800	7362272	6595204	89.58
2_41	15478054	11536741	10397524	90.13
2_43	8412374	6457358	5684473	88.03
2_46	9201810	7199387	6628735	92.07
2_52	15917652	10999803	10109761	91.91

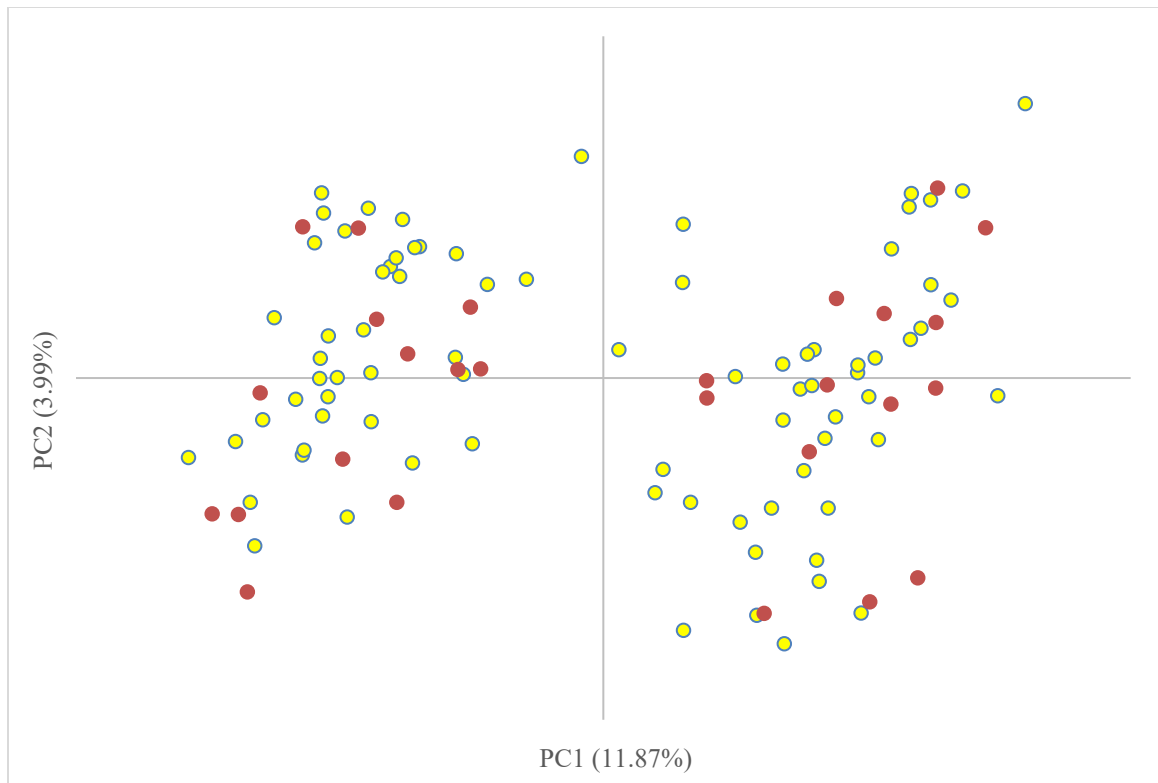
2_63	2153072	1389526	1075713	77.42
2_64	8826610	6020726	5368822	89.17
2_69	9683162	6844112	6136103	89.66
2_70	18131408	13336552	12512211	93.82
2_80	13522752	9621189	9102655	94.61
2_82	11802338	9495029	8692032	91.54
2_94	8381174	5923143	5152520	86.99
2_98	15975852	11197840	10454322	93.36
3_1	10289042	8114136	7545553	92.99
3_100	12191650	8711913	8030694	92.18
3_102	22406282	14600327	12859645	88.08
3_10	14462432	12217402	11281959	92.34
3_15	12855412	10060618	9077928	90.23
3_20	13312718	9903660	8776740	88.62
3_21	9200796	7826116	7092997	90.63
3_30	13826628	11205742	9866055	88.04
3_33	13874428	9883554	8948437	90.54
3_40	22020118	15391979	14004913	90.99
3_50	21287488	16249440	15009879	92.37
3_54	10535870	8968934	7936281	88.49
3_60	13396782	11211522	10003576	89.23
3_70	485790	373333	338721	90.73
3_80	28539386	15717478	13857290	88.16
3_87	10843344	8638638	7785489	90.12
3_94	19720616	13199353	11620661	88.04
3_98	5264680	3499644	2935262	83.87
4_1	16726828	11960701	11440174	95.65
4_4	11149992	8577730	7700857	89.78
4_100	14751912	10332865	9563878	92.56
4_102	20838628	16307826	14896545	91.35
4_10	10432622	8428158	7818221	92.76
4_126	10491906	7119363	6272966	88.11
4_12	11954874	8779802	7889695	89.86
4_21	13257928	9347680	8468457	90.59
4_30	15411808	9151715	8675218	94.79
4_40	15074350	11023119	10027959	90.97
4_52	4823704	3543940	3337605	94.18
4_55	11231614	8928913	8196466	91.80
4_66	12830178	10225514	9048578	88.49
4_80	16415280	11523120	10627893	92.23
4_84	10408328	8898485	7359591	82.71

4\_95      10765874      8208058      7429179      90.51



**Figure 4.1** Manhattan Plots for 13 traits. A) X-axis displays chromosomes one through seven. Y-axis displays  $-\log_{10}$  of raw p-values for each SNP. Each point represents an individual SNP with the black horizontal bar being placed at  $-\log_{10} p = 2$  which roughly

correlates to an adjusted p-value of  $\sim 0.1$ . **B)** Manhattan plots for the two traits with statistically significant associations after very stringent Bonferroni adjustment. The red line shows a significance threshold of  $p < 0.05$  after Bonferroni adjustment.



**Figure 4.2** PCA of SNPs called for all sequenced individuals in the F2 population. Red points are individuals that segregated into the smaller, “*texensis*-like” cluster in the phenotypic PCA, yellow points are individuals that segregated into the larger, “*canadensis*-like” cluster in the phenotypic PCA (figure 3.5).

### **Discussion**

The F2 population may have higher heterozygosity than anticipated because the F0 parents are not recombinant inbred lines but wildtype *Cercis canadensis*. I plan to confirm levels of heterozygosity in the F0 parents prior to publication of this data. The

increased heterogeneity from the addition of the open-pollinated F1s made identifying QTL's with the Khufu pipeline impossible.

Despite these complications, by performing a GWAS and accounting for population structure through a PCA of each genotype, we were able to identify numerous loci statistically linked to the traits of interest. Individual SNPs with extremely high negative log<sub>10</sub> p-values are more likely to be false positives rather than true trait loci. It is unlikely that we were able to call individually segregating SNPs with any level of certainty given the low coverage depth of the data and the heterogeneity of the population. Many of the traits have multiple peaks of interest in the Manhattan plots; however, all except leaf thickness and tree height, fall below the  $p < 0.05$  significance threshold after Bonferroni correction (figure 4.1B). Tree height (130 SNPs) was one of four traits influencing separation of the clusters of individual F2s in the morphometric PCA (Figure 3.5). By comparison, leaf thickness was a much more continuous trait (Figure 3.5). The significantly associated SNPs for tree height on chromosomes five and six imply that this trait is controlled in a simpler way when compared to leaf thickness. However, for both traits, the associated loci are unlikely to be homologous in more distantly related plant taxa (i.e. outside the genus *Cercis*) the more distantly related that taxon is. Additionally, it is unlikely that tree height is being controlled by a small number of “core” genes. A more plausible explanation is that this trait is controlled by a large suite of linked genes. For all measured traits, it is likely that there are multiple loci across multiple chromosomes controlling them rather than a single master locus controlling each.

I was able to identify the general regions of the chromosomes responsible for those traits, regions which contain hundreds of genes. Reconciliation of genomic and morphometric data can play out in multiple ways. If genes underlying morphological traits prove impossible to identify even with deep sequencing coverage and a large sample size, this implies that the observed variation is unlikely to have a strong genetic control. Conversely, if there are clear loci linked to each trait, this implies that the genes underlying that trait are the primary driver of that variation but it may be difficult to pin to a single gene. In this study the identification of linked SNPs suggests that variation is likely driven by both genetic and environmental factors. The complexity of the genetic basis for the measured phenotypic traits implies that an infraspecific ranking is appropriate for these taxa. It is encouraging that clustering of individuals based purely on phenotype (chapter 3) does not match the clustering of individuals based on the genotypic data. Because the individuals grouping in the morphometric and color analyses (figures 3.5, 3.6, and 3.7) are widespread in the SNP-based PCA (figure 4.2) we should have the power to identify loci linked with these traits even after adjusting for population structure and kinship. Ultimately, this work shows that phenotype and genotype can be reconciled in a utilitarian way and has implications for future taxonomic and conservation efforts. These results can help horticulturists with future breeding efforts like marker assisted selection and show that phenotypic traits can be reconciled in a genomic context.

Additional work to remove the individuals that are not from the controlled F2 cross by calling SNPs in the F0 parents and determining individuals with SNP calls not from either parent across multiple kmers may increase clarity for all analyses.

## CHAPTER 5

### CONCLUSIONS AND FUTURE DIRECTIONS

#### Conclusions

While North American *Cercis* are not of conservation concern, they are prevalent in horticultural settings and throughout southeastern forests where they may be filling an important ecological niche. Their prevalence throughout much of the US's natural areas makes them helpful in answering questions regarding species delimitation and environmental effects on genetic and morphologic variation. By using them to develop an in-depth framework for inter- and intraspecies delimitation I hope to enable future work in systems of conservation importance. The Endangered Species Act (ESA) aims to protect all species under threat of imperilment but is limited by its wording. It only provides protection to plants that have clear species or subspecies definitions. Lower-level taxonomic rankings are often considered less valuable in the eyes of governmental interpretation of conservation efforts because infraspecific taxonomic designations are hypothesized to represent phenotypic variation at a population-specific or community-specific level. This judgement of value of a taxonomic group attempts to maximize pragmatism within a regulatory system limited by resource availability. Taxonomic anarchy (disagreement on what constitutes a species within the literature and among experts) is one of the main drivers of limitations regarding the ESA (Garnett & Christidis, 2017; Thomson et al., 2018). Having clear goals for conservation efforts such as particular species or subspecies is required to apply it effectively.

Extensive morphometrics and identification of loci underlying traits used for taxonomic delimitation is the first step to this pluralistic approach to taxonomic delimitation. While DeSalle et al. (2018) contend that their “unholy trinity” is intended as part of a theoretical framework for the incorporation of DNA barcoding into taxonomic delimitation, I would argue that their taxonomic circle (more of a pentagram) of delimitation lays the groundwork for an operational approach to using the Pluralistic Species Concept (Figure 3.1). Their approach can be interpreted as being genomic-centered as their work is framed as a way to incorporate genomic data into each of the prongs used in species delimitation. The approach they outline (i.e. only two of the five prongs are necessary to delimit species, one of which should be genomics) is less resource intensive, but only provides a snapshot of the reality of species boundaries. By expanding to include at least some aspect of each point of the pentagram, a wholistic view of species boundaries can be achieved. This approach is at the heart of the Pluralistic Species Concept.

The common garden accessions of *Cercis canadensis* varieties show some morphological distinction for traits like leaf width and leaf length. However, when put into the larger perspective of the wild accessions examined by Fritsch et al., those groups become less pronounced. Distinct groups based on leaf length and width also segregate in approximately one fifth of the plants sampled from the F2 breeding population (Figure 3.5). In contrast, traits like leaf sinus shape, leaf apex shape, fruit length, fruit width, fruit wing width, and flower length do not form distinct groups and instead appear continuous. Based on these results there is evidence that these traits are somewhat affected by environment.

The F2 population is more heterogeneous than expected of a typical F2 breeding population rendering a formal QTL analysis with no statistically linked traits. However, trait variation was associated with multiple loci identified through a GWAS. As expected for quantitative traits, there are likely multiple genes underlying these traits. Nonetheless, the results of the GWAS analyses (Fig. 4.1) show that variation in key traits (those used for historic taxonomic delimitation) have a genetic basis. Much more work would be necessary to identify the specific genes underlying the morphological trait variation but the GWAS associations support the assumption of morphology-based taxonomic circumscription that variation in key traits has a genetic basis. My approach of reconciling morphometric data from wild and common garden plants of the same taxa with the genes underlying those traits should also enable delimitation in other taxonomic systems of conservation importance. My work supports the work of Clausen et al. 1939 (i.e. phenotypic plasticity is likely responsible for some variation between taxa regardless of rank). Despite differing morphometrics of plants grown in a common garden versus wild types, a QTL or GWAS analysis can elucidate a genetic basis for variation in key traits. Ultimately, taxonomic delimitation is important but complex and my work shows that reconciliation of phenotypic and genomic data is possible. Therefore, the modern taxonomist should consider the complexity of genetic and environmental influences on the diagnostic traits used to differentiate taxa prior to designating taxonomic rank.

### **Future Directions**

I plan to expand this study by assessing genome-wide patterns of variation within and among all *Cercis* species. Elucidating relationships within *Cercis* may be complicated given their recent diversification (~16mya) (Fritsch et al., 2018). I will identify putatively

single copy genes based on ortholog clustering in other available legume genomes using Orthofinder2 (Emms & Kelly, 2019). Orthologous gene sequences will be aligned and used to make gene trees and a lineage tree using PASTA, IQtree, and ASTRAL, respectively (Mirarab et al., 2015; Nguyen et al., 2015; Zhang et al., 2018). The resulting gene and lineage trees will be used to quantify support for taxon relationships and the degree of gene tree discordance than may be due to incomplete lineage sorting and geneflow as lineages are diverging.

By comparing a whole-genome phylogeny (lineage tree) to gene trees for the traits used in taxonomic delimitation I can assess gene tree – lineage tree discordance which may inform taxonomic circumscription (Sukumaran & Knowles, 2017). Discordance among gene trees and taxon relationships may be driven by persistence of selectively neutral ancestral variation (incomplete lineage sorting), adaptive segregation of ancestral variation of adaptive non-synonymous substitutions that occurred after speciation and were driven to high frequency or fixation within species lineages, and/or inter-specific gene flow (Pease et al., 2016). Adaptive non-synonymous substitutions that occurred after speciation could drive fixation of alleles between speciation events resulting in concordance with species trees. But incomplete lineage sorting could lead to misinterpretation of taxonomic groupings (i.e. lumping or splitting of taxa).

Introgression (movement of genes from one species into another through hybridization and backcrossing) can re-introduce previously lost ancestral variation. To identify introgression and admixture, D-statistics and fastSTRUCTURE will be used, respectively. Allele frequencies for each SNP will be calculated. Then D-statistics will be used to estimate the the level of introgression. In some cases, D-values are almost entirely

driven by small windows of localized introgression rather than genome-wide introgression (Pease et al., 2016). This can be determined through sliding-window analyses. Calculating the D-statistics for genes containing high allelic variation and comparing with genome-wide D-statistics should allow for more accurate interpretation of introgression. To genotype clusters, multi-locus SNP profiles for each genotype will be input to fastSTRUCTURE to assess whether any genotypes or taxa exhibit evidence of admixture.

I plan to identify clade-specific traits correlated with one or more environmental variables as identified in Fritsch et al. (2018). Traits found to be robust to environmental effects are not considered lineage specific and thus will be excluded from further analysis. Linking morphological traits to environmental data through environment specific SNPs may provide further evidence as to the legitimacy of current taxonomic circumscriptions. Altitude, temperature, and precipitation for each accessions' provenance location will be extracted from the WorldClim database ([www.worldclim.org](http://www.worldclim.org)). Soil data at 1 km resolution will be obtained from the ISRIC SoilGrids project (<http://soilgrids.org/>). Every set of two environment factors will be used to create environmental contrasts. All accessions for each working group will be treated as populations with shared environmental habitats and analyzed for nonsynonymous variations unique to each working group and environmental contrast pair. Significance will be assessed through simulations performed in the programs (Hudson & Coyne, 2002). The lineage tree produced using ASTRAL will be used to provide context for determining which environment variables are worth investigating. For example, if accessions sharing an acuminate leaf tip cluster together compared to accessions with a retuse leaf tip exploring data relative to drought may be more likely to explain the data. The role of leaf tip shape in drought tolerance was discussed by Fritsch

(2018). However, leaf tip shape seems to be relatively plastic (chapter 3) and may not be ideal as the sole trait for taxonomic determination between “canadensis” and “texensis”.

These proposed studies effectively incorporate 4/5 prongs (DNA, morphology, geography, ecology) of the taxonomic circle described by (De Salle et a. (2018). Additional work to explore the reproductive biology of *Cercis* will also be required.

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## APPENDICES

### APPENDIX A

#### **R Code for Principal Component Analyses**

```
library("FactoMineR")
library("factoextra")
library("ggplot2")
setwd("C:/Users/mason/OneDrive - University of
Georgia/Cercis")

#Common Garden PCA
df <- read.csv("Morphometrics.csv", header = TRUE)
rownames(df) <- df[,1]
df <- subset(df, df$Working_group != "CGM")
head(df)

df.active <- df[,2:14] #have to use numeric only
head(df.active)
df.active$Working_group <-
as.numeric(as.factor(df.active$Working_group))
pca <- PCA(df.active[1:12], scale.unit = TRUE, ncp = 5,
graph = TRUE)

pca$eig
pca$var

plot(pca$ind$coord[,1:2])

pca$call$X$Group <- as.numeric(as.factor(df$Working_group))

g1<-plot(pca, axes = c(1,2), choix = "ind", habillage = 13,
col.hab = df$Working_group)+
  binned_scale(aesthetics = "color",
               scale_name = "stepsn",
               palette = function(x) c("red", "yellow",
"green", "blue"),
               breaks = c(1, 2, 3, 4),
               limits = c(1, 5),
               show.limits = T,
```

```

        guide = "colorsteps"
    )
g1
ggsave(g1, "nameoffile.svg", width = 10, height = 10, units
= "in", dpi = 500)

coords <- as.data.frame(pca$ind$coord[,1:2])
coords$'Working Group' <- df$Working_group
g2 <- ggplot(coords, aes(x = Dim.1, y= Dim.2, col =
`Working Group`))+
  stat_ellipse(geom = "polygon", type = "norm", alpha =
.15, aes(fill = `Working Group`))+
  geom_point()+
  ylim(-6,6)+
  xlim(-8,6)+
  geom_hline(yintercept = 0, lty =2)+
  geom_vline(xintercept = 0, lty = 2)+
  #stat_ellipse(type = "norm")+
  theme_classic()+
  scale_color_manual(values = c("#F8E051", "#83C6EB",
"#F67BC3", "#94413A"))+ #put in hex colors here
  scale_fill_manual(values = c("#F8E051", "#83C6EB",
"#F67BC3", "#94413A"))+ #put in hex colors here
  xlab("Dim 1 (41.37%)" )+
  ylab("Dim 2 (16.21%)" )+
  theme_classic()
g2

vars <- data.frame(x = pca$var$cor[,1]*7.3, y =
pca$var$cor[,2]*7.3, label =1:12)
vars[9, ] <- c(-.25, -.25, 9)
g2 <-
  ggplot(coords, aes(x = Dim.1, y= Dim.2, col = `Working
Group`))+
  stat_ellipse(geom = "polygon", type = "norm", alpha =
.15, aes(fill = `Working Group`))+
  geom_point()+
  geom_segment(data = data.frame(pca$var$cor), aes(x =0, y=
0, xend = Dim.1*7, yend = Dim.2*7), arrow = arrow(angle=
30, length = unit(.05, "in")), col = "black")+ #the number
you multiple by will just determine how far out you want
the lines
  annotate("text", x = vars$x, y = vars$y, label
=vars$label)+
  geom_hline(yintercept = 0, lty =2)+

```

```

    geom_vline(xintercept = 0, lty = 2)+
    #stat_ellipse(type = "norm")+
    theme_classic()+
    scale_color_manual(values = c("#F8E051", "#83C6EB",
"#F67BC3", "#94413A"))+ #put in hex colors here
    scale_fill_manual(values = c("#F8E051", "#83C6EB",
"#F67BC3", "#94413A"))+ #put in hex colors here
    xlab("Dim 1 (41.37%)" )+
    ylab("Dim 2 (16.21%)" )+
    theme_classic()
g2
ggsave(plot = g2, filename = "CommonGardenPCA.svg", device
= "svg", width = 10, height = 10, units = "in", dpi = 500)

##### Pheno PCA #####
F2phenol <- read.csv("F2phenotypes1_norm.csv") #this is
just sheet2 from the .xlsx you sent me
# we have missing values so we want to impute (estimate)
from the data we have first
library(missMDA)
#first step, determine how many components are used to
estimate missing data
nb <- estim_ncpPCA(F2phenol[,2:14],ncp.max=5, ncp.min = 0)
## results in 0 AKA we can just use averages
F2phenol_corrected <- imputePCA(F2phenol[,2:14], ncp =
nb$ncp, scale = F, method = "Regularized")
pca_F2phenol <- PCA(F2phenol_corrected$completeObs,
scale.unit = TRUE, ncp = 5, graph = TRUE)

pca_F2phenol$ind

fviz_pca_ind(pca_F2phenol,
             geom.ind = "point",
             label = "none",

             addEllipses = TRUE,
             palette =
c("steelblue", "forestgreen", "darkgray"))

coords2 <- as.data.frame(pca_F2phenol$ind$coord[,1:2])
coords2$group <- substr(F2phenol$Sample., 1, 1)
coords2$group[115] <- "10"
coords2$group[116] <- "9"

```

```

#ellipses colored by row
g3 <- ggplot(coords2, aes(x = Dim.1, y= Dim.2, col =
group))+
  stat_ellipse(geom = "polygon", type = "norm", alpha =
.25, aes(fill = group))+
  geom_point()+
# geom_segment(data = data.frame(pca_F2phenol$ind$coord),
aes(x =0, y= 0, xend = Dim.1*7, yend = Dim.2*7), arrow =
arrow(angle= 30, length = unit(.05, "in")), col = "black")+
#display component loadings; the number you multiple by
will just determine how far out you want the lines
# annotate("text", x = vars$x, y = vars$y, label
=vars$label)+ #how to annotate the component loadings
  geom_segment(data = data.frame(pca_F2phenol$var$coord),
aes(x =0, y= 0, xend = Dim.1*7, yend = Dim.2*7), arrow =
arrow(angle= 30, length = unit(.05, "in")), col = "black")+
#the number you multiple by will just determine how far out
you want the lines
  annotate("text", x = vars3$x, y = vars3$y, label
=vars3$label)+
  xlim(-6.5,6.5)+
  ylim(-4.25,4.25)+
  geom_hline(yintercept = 0, lty =2)+
  geom_vline(xintercept = 0, lty = 2)+
  theme_classic()+
  scale_color_manual(values = c("#CDFA21", "#000000",
"#8EC6EB", "#F67BC3", "#94413A", "#000000"))+ #can change
this so it's less ugly or remove it completely
  scale_fill_manual(values = c("#CDFA21", "#000000",
"#8EC6EB", "#F67BC3", "#94413A", "#000000"))+
  xlab("PC 1 (18%)" )+
  ylab("PC 2 (13.9%)" )+
  theme_classic()
g3

```

```

coords3 <- as.data.frame(pca_F2phenol$ind$coord[,1:2])
coords3$Legend <- "F2"
coords3$Legend[115] <- "C. c. var. canadensis 'Appalachia
Red'"
coords3$Legend[116] <- "C. c. var. texensis 'Oklahoma'"
coords3 <- cbind(coords2, F2phenol_corrected$completeObs)
coords3$LeafLengthBin <- ifelse(coords2$Leaf.Length < -1,
"Small Leaf", "Big Leaf")
coords3

```

```

vars3 <- data.frame(x = pca_F2phenol$var$coord[,1]*7.5, y =
pca_F2phenol$var$coord[,2]*7.5, label =1:13)
vars3[8,1] <- 1
vars3[9,1] <- 0.9

g4 <- ggplot(coords3, aes(x = Dim.1, y= Dim.2))+
  stat_ellipse(geom = "polygon", type = "norm", alpha =
.15, aes(col = LeafLengthBin, fill = LeafLengthBin))+
  geom_point(aes(col = Legend, pch = Legend, size =
Legend))+
  geom_segment(data = data.frame(pca_F2phenol$var$coord),
aes(x =0, y= 0, xend = Dim.1*7, yend = Dim.2*7), arrow =
arrow(angle= 30, length = unit(.05, "in")), col = "black")+
#the number you multiple by will just determine how far out
you want the lines
  annotate("text", x = vars3$x, y = vars3$y, label
=vars3$label)+
  #xlim(-6.5,6.5)+
  #ylim(-4.25,4.25)+
  geom_hline(yintercept = 0, lty =2)+
  geom_vline(xintercept = 0, lty = 2)+
  theme_classic()+
  scale_color_manual(values = c("#F8E051","#F8E051",
"#94413A","#000000", "#94413A"))+ #can change this so it's
less ugly or remove it completely
  scale_fill_manual(values = c("#F8E051",
"#94413A", "#000000", "#000000", "#000000"))+
  scale_shape_manual(values = c(19, 18, 3))+ #for the three
types (babies, parent 1, parent 2)+
  scale_size_manual(values = c(3, 3.5, 1.5))+
  xlab("PC 1 (20.4%)" )+
  ylab("PC 2 (13.7%)" )+
  theme_classic()+
  guides(fill = "none", color = "none", shape =
guide_legend(override.aes = list(col = c("#F8E051",
"#94413A", "#000000"))))
g4
ggsave(plot = g4, filename = "F2PCA.svg", device = "svg",
width = 15, height = 10, units = "in", dpi = 500)

```

## APPENDIX B

### **R Code for Color Distance & Confirmation Tests (PCA & NMDS)**

```
#Script for analyzing color distance between sample images
https://hiweller.github.io/colordistance/colordistance-
introduction.html

#Load colordistance package
library(colordistance)

#set upper and lower limits for white background
upper <- c(1, 1, 1)
lower <- c(0.99, 0.99, 0.99)
#
# #Pipeline for individual image analysis
#
# #load individual image into R
Cercis <- colordistance::loadImage("1-1.jpeg", lower=lower,
upper=upper)
dim(Cercis)
#get histogram for individual image using a 2x2x2 bin for
colorspace
colordistance::getImageHist(Cercis, bins=c(2, 2, 2),
lower=lower, upper=upper)
get pixel plot for individual image
colordistance::plotPixels(Cercis, lower=lower, upper=upper)

#Batch pipeline
#create list of all files in this directory; assumes all
images have been pre-segmented and background removed and
substituted with a solid white background
files<- list.files("~/Downloads/Cercis_Sample")
images <- "~/Downloads/Cercis_Sample"
#run the preset default pipeline for analysis (assumes
bright green background)
colordistance::imageClusterPipeline(colordistance::loadImage
e(images), lower, upper)

#creates a list of dataframes using the histogram bins for
each image with 2x2x2 bins per image
```

```

histList <- colordistance::getHistList(images, lower=lower,
upper=upper, bins=rep(2, 3), plotting=FALSE, pausing=FALSE)
n <- 12 #number of photos; in this case 12
rgb_int <- list()
for(i in 1:n){
  rgb_int[[i]] <-
6536*histList[[i]][,1]+256*histList[[i]][2]+histList[[i]][,
3]
}
# #Output is that each list = each image and each row in
each list are the colors for the 8 pixels in each image

#creates a list of dataframes using kmeans for each image
kmeansBinning <-
colordistance::imageClusterPipeline(images, cluster.method
= "kmeans", upper = upper, lower = lower)
#create a color distance matrix

##### Extracting from csv #####
setwd("C:/Users/mason/OneDrive - University of
Georgia/Cercis/color analysis")
F2pheno2 <- read.csv("F2pheno2.csv")
#each image has 9 values (3X3 pixels). Need to put into a
list for colordistance package
rel <- F2pheno2[,c("Sample", "R", "G", "B", "Dens")]
names(rel) <- c("ID", "r", "g", "b", "Pct")
rel$Pct <- as.numeric(rel$Pct)
histList <- list()
for(i in 1:length(unique(rel$ID))){
histList[[i]] <- rel[rel$ID %in% unique(rel$ID)[i],2:5]
}
names(histList) <- unique(rel$ID)
names(histList)
CDM_large <-
colordistance::getColorDistanceMatrix(histList,
method="emd", plotting=FALSE)
dev.off() #for some reason my comptuer does not like this
heatmap thing
colordistance::heatmapColorDistance(CDM_large, col =
colorRampPalette(c("#F8E051", "#94413A"))(299), margins =
c(8,2)); text(x = 0, y = 1, "meep")

#### Testing heatmap #####

```

```

#if you want to do this on any of the smaller ones, you'll
need to repeat all the code below but using CDM_small
instead.
obj <- CDM_large
clust <- as.dist(obj)
dev.off()
jpeg("CDM_big.jpeg", width = 12, height = 12, units = "in",
res = 600)
gplots::heatmap.2(obj, symm = TRUE, col =
colorRampPalette(c("#F8E051", "#94413A"))(299),
Rowv = as.dendrogram(hclust(clust)),
trace = "none",
density.info = "none",
key = F, revC = T, srtCol = -90, na.color
= "grey",
margins = c(5,3), offsetRow = 0,
offsetCol = 2, cexCol = .6, lwid= c(2, 25), lhei = c(1,5))
dev.off()
#### End of Test (success?)

for(k in 1:123){
  histList[[k]][,5] <-
6536*histList[[k]][,1]+256*histList[[k]][,2]+histList[[k]][
,3]
  histList[[k]][,6] <- (histList[[k]][,5])^2
}
avg_rgb <- array()
for(i in 1:123){
  avg_rgb[i] <- sqrt(sum(histList[[i]][,6])/6)
}
short_List <- as.data.frame(t(col2rgb(avg_rgb, alpha =
FALSE)))/255
short_List$Pct <- 1
names(short_List) <- c("r", "g", "b", "Pct")
short_hist <- list()
for(i in 1:nrow(short_List)){
  short_hist[[i]] <- short_List[i,]
}
names(short_hist) <- unique(rel$ID)

#dev.off()
CDM_small <-
colordistance::getColorDistanceMatrix(short_hist,
method="emd", plotting=FALSE)
#print(CDM_small)

```

```

#create a heatmap to visualize color differences between
images
colordistance::heatmapColorDistance(CDM_small, col =
colorRampPalette(c("#F8E051", "#94413A"))(299))
jpeg("CDM_small.jpeg", width = 12, height = 12, units =
"in", res = 600)
#export color data for external analysis
write.csv(CDM_large, file =
"Cercis_color_distance_matrix_large.csv")
#export newick tree to show relationships between colors
colordistance::exportTree(CDM_large, file =
"Cercis_color_tree_large.newick", return.tree = F)
#export color data for external analysis
write.csv(CDM_small, file =
"Cercis_color_distance_matrix_small.csv")
#export newick tree to show relationships between colors
colordistance::exportTree(CDM_small, file =
"Cercis_color_tree_small.newick", return.tree = F)

##### Alternative A - 3 figures, 1 for each color component
(r,g,b) at the pixel level ###
setwd("C:/Users/mason/OneDrive - University of
Georgia/Cercis/color analysis")
library(ggplot2)
F2pheno2 <- read.csv("F2pheno2.csv")
#each image has 9 values (3X3 pixels). Need to put into a
list for colordistance package
rel <- F2pheno2[,c("Sample", "R", "G", "B", "Dens")]
names(rel) <- c("ID", "r", "g", "b", "Pct")
rel$Pct <- as.numeric(rel$Pct)
histList_r <- list()
for(i in 1:length(unique(rel$ID))){
  histList_r[[i]] <- rel[rel$ID %in% unique(rel$ID)[i],2:5]
  histList_r[[i]][,2:3] <- 0
}

names(histList_r) <- unique(rel$ID)
CDM_r <- colordistance::getColorDistanceMatrix(histList_r,
method="emd", plotting=FALSE)
#print(CDM_small)
#create a heatmap to visualize color differences between
images
dev.off()

```

```

jpeg("Red_comparison.jpeg", width = 11, height = 11, units
= "in", res = 600)
colordistance::heatmapColorDistance(CDM_r, col =
colorRampPalette(c("#FFFFFF", "#FF0000"))(299))
dev.off()
#This plot is for comparing reds

#Now we compare blues
histList_b <- list()
for(i in 1:length(unique(rel$ID))){
  histList_b[[i]] <- rel[rel$ID %in% unique(rel$ID)[i],2:5]
  histList_b[[i]][,c(1:2)] <- 0
}

names(histList_b) <- unique(rel$ID)
CDM_b <- colordistance::getColorDistanceMatrix(histList_b,
method="emd", plotting=FALSE)
#print(CDM_small)
#create a heatmap to visualize color differences between
images
dev.off()
jpeg("Blue_comparison.jpeg", width = 11, height = 11, units
= "in", res = 600)
colordistance::heatmapColorDistance(CDM_b, col =
colorRampPalette(c("#FFFFFF", "#0000FF"))(299))
dev.off()

#Now we compare greens
histList_g <- list()
for(i in 1:length(unique(rel$ID))){
  histList_g[[i]] <- rel[rel$ID %in% unique(rel$ID)[i],2:5]
  histList_g[[i]][,c(1,3)] <- 0
}

names(histList_g) <- unique(rel$ID)
CDM_g <- colordistance::getColorDistanceMatrix(histList_g,
method="emd", plotting=FALSE)
#print(CDM_small)
#create a heatmap to visualize color differences between
images
dev.off()
jpeg("Green_comparison.jpeg", width = 11, height = 11,
units = "in", res = 600)
colordistance::heatmapColorDistance(CDM_g, col =
colorRampPalette(c("#FFFFFF", "#006400"))(299))

```

```

dev.off()

##### Alternative B - PCA of colors ###
library("FactoMineR")
library("factoextra")
setwd("C:/Users/mason/OneDrive - University of
Georgia/Cercis/color analysis")
library(ggplot2)
F2pheno2 <- read.csv("F2pheno2.csv")

pca_colors <- PCA(F2pheno2[,c(3:5)], scale.unit = TRUE, ncp
= 5, graph = TRUE)
coords <- as.data.frame(pca_colors$ind$coord[,1:2])
coords$Sample <- F2pheno2[,1]
#coords$Row <- as.numeric(substr(F2pheno2$Sample, 1, 1))
#coords$column <- as.numeric(substr(F2pheno2$Sample, 3,
nchar(F2pheno2$Sample)))
#coords <- cbind(coords, F2pheno2[,3:5])
vars <- data.frame(x = pca_colors$var$cor[,1]*7.3, y =
pca_colors$var$cor[,2]*7.3, label =c("R", "G", "B"))
#g2 <-
ggplot(coords, aes(x = Dim.1, y= Dim.2))+
  geom_point(pch = 19, cex = .75, col = "grey50")+
  geom_segment(data = data.frame(pca_colors$var$cor), aes(x
=0, y= 0, xend = Dim.1*7, yend = Dim.2*7), arrow =
arrow(angle= 30, length = unit(.05, "in")), col = "black")+
  annotate("text", x = vars$x, y = vars$y, label
=vars$label)+
  geom_hline(yintercept = 0, lty =2)+
  geom_vline(xintercept = 0, lty = 2)+
  #stat_ellipse(type = "norm", aes(col = Sample))+
  theme_classic()+
  #scale_color_manual(values = c("red", "blue", "yellow",
"green", "purple"))+ #put in hex colors here
  #scale_fill_manual(values = c("red", "orange", "blue",
"pink", "brown"))+ #put in hex colors here
  xlab("Dim 1 (92.35%))+
  ylab("Dim 2 (6.08%))+
  theme_classic()+
  ggtitle("PCA of Color")
ggsave("PCA_color.jpeg", device = "jpeg", , width = 12,
height = 12, units = "in", dpi = 600)

##### Alternative 3 - NMDS of Distance Matrix #####
library(vegan)

```

```

setwd("C:/Users/mason/OneDrive - University of
Georgia/Cercis/color analysis")
F2pheno2 <- read.csv("F2pheno2.csv")
#each image has 9 values (3X3 pixels). Need to put into a
list for colordistance package
rel <- F2pheno2[,c("Sample", "R", "G", "B", "Dens")]
names(rel) <- c("ID", "r", "g", "b", "Pct")
rel$Pct <- as.numeric(rel$Pct)
histList <- list()
avg_r <- avg_g <- avg_b <- array()
for(i in 1:length(unique(rel$ID))){
  histList[[i]] <- rel[rel$ID %in% unique(rel$ID)[i],2:5]
  avg_r[i] <- mean(histList[[i]]$r)
  avg_b[i] <- mean(histList[[i]]$b)
  avg_g[i] <- mean(histList[[i]]$g)
}
names(histList) <- unique(rel$ID)

CDM_large <-
colordistance::getColorDistanceMatrix(histList,
method="emd", plotting=FALSE)
mds_1 <- metaMDS(CDM_large,
  distance = "bray",
  k = 1,
  maxit = 999,
  trymax = 500,
  wascores = TRUE)
mds_3 <- metaMDS(CDM_large,
  distance = "bray",
  k = 3,
  maxit = 999,
  trymax = 500,
  wascores = TRUE)
mds_2 <- metaMDS(CDM_large,
  distance = "bray",
  k = 2,
  maxit = 999,
  trymax = 500,
  wascores = TRUE)
mds_4 <- metaMDS(CDM_large,
  distance = "bray",
  k = 4,
  maxit = 999,
  trymax = 500,
  wascores = TRUE) #this one takes awhile

```

```

plot(c(1:4), c(mds_1$stress, mds_2$stress, mds_3$stress,
mds_4$stress), type = "o", main = "Stress Plot", xlab =
"Number of Dimensions", ylab = "Stress", ylim = c(0,.2))

#we want to see stress decrease and then find the point
where more dimensions doesn't really help. Looks like in
this case, we want to use 3 dimensions. We want stress <.1
if possible
stressplot(mds_3)
#pretty decent correlation, meaning we can trust the
results of this nmms

plot(mds_3)
ordiplot(mds_3, type="n")
jpeg("Red_NMDS.jpeg", width = 11, height = 8, units = "in",
res = 600)
ordisurf(mds_3, avg_r, col="red", main = "Grouping by Red in
Image")
dev.off()
jpeg("Blue_NMDS.jpeg", width = 11, height = 8, units =
"in", res = 600)
ordisurf(mds_3, avg_b, col="blue", main = "Grouping by Blue
in Image")
dev.off()
jpeg("Green_NMDS.jpeg", width = 11, height = 8, units =
"in", res = 600)
ordisurf(mds_3, avg_b, col="green", main = "Grouping by Green
in Image")
dev.off()

jpeg("Red_labeled_NMDS.jpeg", width = 11, height = 8, units
= "in", res = 600)
ordisurf(mds_3, avg_r, col="red", main = "Grouping by Red in
Image", cex = 0); orditorp(mds_3, "sites", cex = .5, air =
0.1)
dev.off()

```

APPENDIX C

Raw F2 Morphometric Data (not including color data)

Sampl e #	Leaf Thickness	Leaf Sinus Shape	Apex Shape	Leaf Width	Leaf Length	Glossy	Leaf Pubescence	Flower Length	Fruit Length	Fruit Width	Fruit Wing Width	Branch Height	Tre e Width	Tre e height
1_04	0.277	5.000	2.000	99.150	73.407	0.000	0	11.402	50.625	11.541	1.255	152.400	152.400	1549.400
1_05	0.260	6.000	4.000	110.715	91.478	1.000	0.5	11.737	64.175	12.410	1.702	254.000	101.600	2070.100
1_07	0.290	4.000	3.000	111.215	94.758	0.000	0.5	11.783	63.010	11.136	1.373	419.100	185.400	2209.800
1_10	0.287	4.000	3.000	96.640	76.980	0.000	0	11.698	NA	NA	NA	202.057	648.919	1109.091
1_11	0.277	4.000	3.000	120.980	94.780	0.000	0.5	11.414	60.03	12.98	1.74	395.656	126.353	2013.433
1_18	0.257	4.000	3.000	96.917	83.820	0.000	1	12.503	52.649	12.433	1.251	228.600	177.800	1714.500
1_19	0.273	4.000	3.000	85.722	75.937	0.000	0.5	12.444	68.651	11.801	1.352	342.900	175.200	1574.800

1_23	0.287	5.000	2.000	97.634	72.841	1.000	0	11.997	57.162	10.359	1.430	444.500	1816.100	2463.800
1_24	0.307	4.000	3.000	104.928	92.412	0.000	1	12.785	53.083	10.954	1.396	520.700	1524.000	2250.000
1_25	0.247	4.000	2.000	99.254	83.755	0.000	0.5	11.571	N/A	N/A	N/A	88.900	1117.600	1473.200
1_26	0.243	4.000	4.000	99.699	93.058	1.000	0.5	N/A	54.268	11.389	1.259	381.000	1066.800	1816.100
1_31	0.237	4.000	3.000	92.687	81.165	0.000	0.5	11.844	52.941	10.909	1.308	88.900	1371.600	2235.200
1_32	0.297	5.000	2.000	118.360	95.430	1.000	0.5	10.530	N/A	N/A	N/A	84.303	1545.082	1827.581
1_33	0.237	6.000	2.000	97.947	72.567	1.000	0.5	11.024	63.916	12.497	1.530	152.400	1422.400	896.620
1_36	0.237	2.000	5.000	100.447	94.416	0.000	0.5	12.039	N/A	N/A	N/A	241.300	1257.300	1930.400
1_37	NA	NA	N/A	NA	NA	0.000	0.5	12.834	N/A	N/A	N/A	NA	NA	N/A
1_38	NA	NA	N/A	NA	NA	0.000	NA	N/A	N/A	N/A	N/A	NA	NA	N/A
1_39	0.267	5.000	3.000	101.849	83.609	0.000	0	12.042	48.578	11.549	1.812	241.300	1257.300	1803.400
1_41	0.277	3.000	2.000	113.770	91.150	1.000	0	12.177	49.640	13.540	3.400	356.692	1713.255	1628.000

														59 7
1_44	0.30 0	5.00 0	3.0 00	94. 274	79. 630	0. 00 0	0	11. 73 9	66. 56 5	11. 89 4	1.6 30	215. 900	939 .80 0	20 57. 40 0
1_46	0.25 3	5.00 0	2.0 00	80. 134	67. 425	1. 00 0	0.5	12. 28 1	64. 35 8	10. 87 4	1.5 66	241. 300	914 .40 0	20 82. 80 0
1_47	0.30 3	5.00 0	3.0 00	110 .89 9	84. 678	0. 00 0	1	12. 67 9	64. 48 6	12. 24 9	1.5 65	190. 500	685 .80 0	13 71. 60 0
1_48	0.28 0	4.00 0	3.0 00	100 .57 0	86. 430	0. 00 0	0.5	13. 37 1	52. 93 5	12. 41 0	1.4 73	177. 800	889 .00 0	15 24. 00 0
1_51	0.26 3	3.00 0	2.0 00	124 .59 0	100 .98 0	0. 00 0	0	11. 62 6	71 .17	14 .67	3. 69	472. 059	106 8.3 75	18 96. 79 6
1_53	0.22 3	4.00 0	3.0 00	93. 942	81. 103	0. 00 0	0.5	13. 18 9	69. 33 0	12. 37 1	1.2 09	584. 200	990 .60 0	22 35. 20 0
1_54	0.24 3	4.00 0	4.0 00	89. 319	76. 709	0. 00 0	0.5	12. 54 1	72. 56 5	12. 35 3	1.7 02	241. 300	165 1.0 00	86 3.6 00
1_57	0.25 3	5.00 0	2.0 00	71. 146	55. 276	1. 00 0	0	N A	N A	N A	N A	165. 100	114 3.0 00	14 98. 60 0
1_59	0.25 0	4.00 0	3.0 00	84. 793	67. 992	0. 00 0	0	12. 85 2	62. 77 9	11. 44 2	1.7 67	203. 200	157 4.8 00	13 20. 80 0
1_60	0.22 7	3.00 0	3.0 00	101 .56 0	83. 380	0. 00 0	0.5	13. 20 4	N A	N A	N A	217. 602	104 1.6 79	10 20. 42 0
1_61	0.32 0	4.00 0	2.0 00	72. 873	55. 682	0. 00 0	0	12. 38 3	N A	N A	N A	203. 200	990 .60 0	10 41. 0

														40 0
1_62	0.27 7	3.00 0	2.0 00	103 .52 0	86. 860	0. 00 0	0	13. 01 5	N A	N A	N A	90.6 78	108 3.1 83	10 91. 99 7
1_67	0.28 7	4.00 0	4.0 00	94. 254	81. 554	0. 00 0	0	12. 38 2	N A	N A	N A	215. 900	180 3.4 00	13 20. 80 0
1_71 A	0.29 3	5.00 0	2.0 00	101 .99 4	77. 852	1. 00 0	0.5	12. 00 8	69. 83 6	12. 46 4	1.5 58	482. 600	NA	N A
1_72	0.27 3	4.00 0	3.0 00	97. 130	80. 220	1. 00 0	0	12. 65 3	N A	N A	N A	41.2 50	881 .35 5	10 89. 73 6
1_74	0.33 0	4.00 0	3.0 00	89. 770	76. 376	0. 00 0	0.5	11. 88 1	63. 27 4	12. 22 8	1.4 88	177. 800	152 4.0 00	16 25. 60 0
1_76	0.32 3	5.00 0	2.0 00	87. 146	66. 283	0. 00 0	0	11. 03 7	70. 09 8	13. 26 6	1.7 36	127. 000	134 6.2 00	14 47. 80 0
1_78	0.26 7	5.00 0	3.0 00	104 .44 2	84. 736	1. 00 0	0.5	11. 99 6	51. 14 7	11. 49 8	1.2 85	330. 200	138 4.3 00	23 87. 60 0
1_79	0.30 0	3.00 0	3.0 00	92. 120	86. 695	0. 00 0	1	13. 43 3	59. 82 3	13. 25 3	1.6 03	NA	193 0.4 00	21 84. 40 0
1_81	0.27 7	5.00 0	4.0 00	115 .71 8	92. 474	0. 00 0	0	11. 24 6	N A	N A	N A	50.8 00	132 0.8 00	11 68. 40 0
1_82	0.31 7	5.00 0	3.0 00	93. 078	73. 444	1. 00 0	0	11. 96 4	N A	N A	N A	431. 800	111 7.6 00	18 79. 60 0
1_85	0.30 0	4.00 0	4.0 00	99. 560	85. 399	0. 00 0	0	N A	N A	N A	N A	203. 200	139 7.0 00	20 44. 00

														70 0
1_87	0.32 3	3.00 0	3.0 00	82. 712	67. 344	0. 00 0	0	11. 58 7	51. 52 9	10. 88 2	1.4 54	279. 400	154 9.4 00	19 68. 50 0
1_88	0.29 0	4.00 0	4.0 00	94. 293	88. 515	0. 00 0	0	11. 48 2	56. 83 5	11. 69 0	1.6 41	292. 100	120 6.5 00	19 68. 50 0
1_89	0.26 0	3.00 0	4.0 00	96. 189	85. 501	0. 00 0	1	12. 63 7	N A	N A	N A	101. 600	116 8.4 00	18 54. 20 0
1_91	0.27 7	4.00 0	3.0 00	106 .23 0	87. 070	1. 00 0	0.5	11. 83 7	64 .94	14 .71	4. 63	436. 016	158 4.4 27	22 80. 59 0
1_92	0.25 0	5.00 0	4.0 00	121 .82 8	97. 817	0. 00 0	0	N A	N A	N A	N A	342. 900	176 5.3 00	22 86. 00 0
2_02	0.32 7	5.00 0	3.0 00	101 .87 8	79. 522	0. 00 0	1	12. 75 5	54. 12 2	12. 47 5	1.5 94	419. 100	154 9.4 00	20 44. 70 0
2_03	0.26 7	6.00 0	4.0 00	88. 208	72. 809	0. 00 0	1	12. 43 9	66. 41 6	12. 39 0	1.9 73	292. 100	193 0.4 00	16 25. 60 0
2_04	0.27 3	6.00 0	2.0 00	92. 244	65. 834	1. 00 0	0.5	N A	N A	N A	N A	171. 450	193 0.4 00	16 25. 60 0
2_07	0.27 7	NA	N A	NA	NA	0. 00 0	NA	13. 62 5	N A	N A	N A	NA	NA	N A
2_09	0.30 0	4.00 0	2.0 00	89. 681	72. 651	0. 00 0	1	12. 81 3	69. 59 0	15. 46 5	1.9 95	444. 500	175 2.6 00	22 60. 60 0
2_10	0.30 0	4.00 0	4.0 00	113 .44 0	96. 400	0. 00 0	0	11. 24 7	67 .64	15 .15	3. 74	265. 760	185 3.0 82	17 09.

														26 8
2_100	0.313	4.000	2.000	116.670	88.440	0.000	0	12.194	N A	N A	N A	361.950	1275.385	1890.725
2_108	0.270	4.000	2.000	97.865	73.743	1.000	0.5	12.348	62.582	11.354	1.400	330.200	1854.200	1041.400
2_127	0.270	3.000	3.000	99.035	92.279	0.000	0.5	12.999	N A	N A	N A	419.100	1803.400	2286.000
2_14	0.253	3.000	3.000	91.994	78.434	0.000	0.5	10.874	N A	N A	N A	400.050	1905.000	2184.400
2_20	0.207	4.000	3.000	107.950	100.090	0.000	0	9.973	63.78	18.24	3.050	411.785	2493.594	1744.294
2_21	0.240	4.000	4.000	98.110	87.540	0.000	0.5	N A	N A	N A	N A	206.375	1137.056	1473.479
2_22	0.277	3.000	3.000	92.003	80.012	0.000	1	12.218	68.293	13.858	1.578	444.500	1384.300	2133.600
2_24	0.243	4.000	2.000	102.102	89.910	0.000	0	12.676	79.129	12.255	2.056	406.400	1549.400	2209.800
2_25	0.270	4.000	4.000	127.851	108.563	0.000	0.5	12.778	70.083	15.131	2.737	558.800	1612.900	2235.200
2_27	0.207	4.000	3.000	89.336	75.945	0.000	0	12.730	65.823	12.854	1.921	431.800	1270.000	2286.000

2_29	0.233	4.000	4.000	103.137	98.162	0.000	0	12.239	56.852	11.759	1.441	355.600	144.7800	19.05000
2_31	0.247	4.000	3.000	118.140	86.830	0.000	1	11.806	64.38	15.25	3.00	393.294	180.5203	23.76957
2_34	0.280	5.000	4.000	95.707	84.271	0.000	1	12.373	68.631	13.846	1.635	330.200	137.1600	20.06600
2_38	0.247	5.000	4.000	90.101	78.217	0.000	0.5	10.991	52.301	12.022	1.560	482.600	965.200	19.55800
2_39	0.180	4.000	3.000	82.597	64.993	0.000	0.5	11.109	N A	N A	N A	0.000	121.9200	13.71600
2_40	0.290	4.000	4.000	13.705	11.578	1.000	0.5	13.633	N A	N A	N A	95.631	772.363	95.7478
2_41	0.277	5.000	4.000	10.571	10.096	0.000	1	12.420	76.64	16.38	3.81	293.395	104.8664	13.51458
2_43	0.247	4.000	3.000	89.078	76.455	0.000	0.5	N A	N A	N A	N A	330.200	137.1600	18.79600
2_46	0.253	4.000	4.000	94.286	86.650	0.000	1	N A	99.388	11.269	2.198	304.800	182.8800	21.08200
2_52	0.243	4.000	3.000	104.510	85.120	0.000	0.5	11.526	68.390	14.35	2.73	182.016	161.9352	17.73072
2_63	0.303	3.000	3.000	124.273	101.425	0.000	0.5	N A	N A	N A	N A	0.000	116.8400	18.79600

2_64	0.240	3.000	3.000	90.865	91.137	0.000	0.5	N A	46.631	13.293	1.502	355.600	127.000	1524.000
2_69	dead	4.000	2.000	113.440	97.430	1.000	0.5	13.123	80.73	16.27	3.57	31.801	120.4189	1207.465
2_70	0.290	6.000	3.000	127.540	100.160	0.000	0	12.611	82.19	17.00	3.27	419.354	180.5508	1542.923
2_80	0.267	4.000	3.000	136.720	106.980	0.000	0.5	12.031	80.97	12.55	3.29	243.307	160.2435	1379.169
2_82	0.290	4.000	4.000	94.920	80.890	0.000	0.5	12.959	N A	N A	N A	140.767	116.9391	1172.388
2_94	0.253	3.000	2.000	94.620	89.272	0.000	0	13.030	65.766	12.449	1.288	0.000	139.700	2209.800
2_98	0.260	3.000	4.000	90.209	89.220	0.000	0	N A	75.104	12.303	1.512	330.200	170.1800	2057.400
3_01	0.257	3.000	3.000	122.300	98.090	0.000	0	12.530	N A	N A	N A	503.707	794.918	1912.518
3_10	0.257	4.000	4.000	105.490	98.240	0.000	1	12.310	N A	N A	N A	311.150	109.9744	1668.069
3_100	0.270	3.000	3.000	106.480	93.240	0.000	1	12.125	64.91	14.06	3.13	367.132	942.721	1448.638
3_102	0.253	NA	N A	NA	NA	0.000	NA	9.513	N A	N A	N A	NA	NA	N A

3_15	0.247	4.000	5.000	91.035	83.734	0.000	0.5	10.242	N A	N A	N A	457.200	185.4.200	16.00.200
3_20	0.263	4.000	3.000	9.397	8.021	1.000	0.5	12.372	N A	N A	N A	513.664	139.9.057	14.85.316
3_21	0.277	5.000	2.000	8.139	6.422	1.000	0.5	11.757	N A	N A	N A	276.682	123.2.052	10.47.699
3_30	0.243	5.000	3.000	9.610	7.505	1.000	0	11.238	N A	N A	N A	354.990	403.301	60.7.746
3_33	0.283	4.000	3.000	11.246	10.000	0.000	0	12.119	.77 .29	14 .46	2. 64	700.329	150.7.261	19.98.370
3_40	0.260	4.000	3.000	14.262	11.248	0.000	1	11.171	.75 .77	14 .05	2. 69	247.345	149.3.139	17.83.867
3_50	0.257	3.000	4.000	10.885	10.369	0.000	0.5	11.121	N A	N A	N A	353.873	168.7.551	12.98.372
3_54	0.243	3.000	3.000	80.021	68.178	0.000	0.5	12.147	64. 371	11. 701	1.8 63	660.400	121.9.200	20.44.700
3_60	0.280	3.000	3.000	11.262	9.733	0.000	0	12.996	N A	N A	N A	220.066	107.2.388	12.28.319
3_70	0.253	4.000	3.000	13.344	9.871	0.000	0	11.941	.55 .10	11 .13	2. 97	373.228	105.9.409	13.44.778
3_80	0.290	4.000	2.000	9.713	8.715	0.000	0.5	11.353	.77 .08	14 .80	3. 80	310.718	161.7.548	18.77.492

3_87	0.237	4.000	4.000	93.189	80.603	0.000	0.5	10.763	58.378	13.697	1.828	457.200	1549.400	2209.800
3_94	0.243	3.000	4.000	107.178	98.933	0.000	0.5	12.628	60.304	11.047	1.378	825.500	1600.200	1854.200
3_98	0.250	4.000	3.000	107.463	78.280	0.000	0.5	11.837	61.258	13.571	1.864	571.500	1879.600	2260.600
4_01	0.247	4.000	3.000	12.295	11.248	1.000	1	12.402	75.55	13.55	2.87	260.020	1185.266	1547.825
4_04	0.300	NA	NA	NA	NA	0.000	0.5	11.428	NA	NA	NA	NA	NA	NA
4_10	0.280	4.000	3.000	9.393	7.600	0.000	0	12.240	NA	NA	NA	204.978	960.374	1384.833
4_100	0.277	4.000	3.000	11.090	10.256	0.000	1	11.602	68.05	13.26	2.37	254.864	916.051	1389.329
4_102	0.310	NA	NA	NA	NA	0.000	NA	13.638	NA	NA	NA	NA	NA	NA
4_12	0.253	4.000	3.000	12.852	10.067	1.000	0.5	NA	NA	NA	NA	276.911	702.513	1553.007
4_126	0.257	NA	NA	NA	NA	0.000	NA	12.182	NA	NA	NA	NA	NA	NA
4_21	0.287	4.000	3.000	8.680	7.328	1.000	0	10.531	59.27	15.46	3.09	509.270	1089.381	2093.392
4_30	0.237	4.000	3.000	13.639	11.978	0.000	1	11.259	NA	NA	NA	510.464	646.582	1121.2

														30 8
4_40	0.267	4.000	3.000	10.967	9.273	0.000	0	12.249	80.78	13.95	3.58	220.370	661.365	1007.770
4_52	0.267	5.000	3.000	13.115	9.279	0.000	0.5	11.643	N A	N A	N A	395.275	688.721	1126.592
4_55	0.280	3.000	3.000	86.790	78.649	0.000	0.5	10.681	65.883	11.795	1.190	127.000	119.380	1879.600
4_66	0.223	4.000	4.000	90.805	76.193	0.000	0	10.875	68.096	13.113	1.862	330.200	149.860	1955.800
4_80	0.297	3.000	3.000	9.852	8.214	0.000	0	10.506	N A	N A	N A	156.413	117.807	923.036
4_84	0.300	NA	N A	NA	NA	0.000	0.5	11.776	N A	N A	N A	NA	NA	N A
4_95	0.307	NA	N A	NA	NA	1.000	0	11.297	N A	N A	N A	NA	NA	N A
av era ge	0.269	4.067	3.076	83.098	69.822	0.211	0.404	12.008	62.809	12.277	1.633	304.935	134.643	1702.999
std ev	0.027	0.800	0.730	36.864	31.029	0.409	0.357	0.823	9.308	1.078	0.362	156.647	375.054	429.810
10 01 64	0.2468	4	3	87.8078	91.0971	0	0	13.056	67.9323	13.1191	1.7272	18.7784	209.4184	127.754
09 00 11	0.3166	5	3	103.9876	81.3689	1	1	10.9728	57.6707	12.6873	2.6289	36.73408	199.86628	161.7299

APPENDIX D

Normalized F2 Morphometric Data (not including color data)

S a m p l e #	Lea f Thi ckn ess	Lea f Sin us Sha pe	Lea f Ap ex Sha pe	Lea f Wi dth	Lea f Le ngt h	Lea f Glo ssy	Lea f Pub esc enc e	Flo wer Le ngt h	Fru it Le ngt h	Fru it Wi dth	Fru it Wi ng Wi dth	Bra nch Hei ght	Tre e Wi dth	Tr ee H ei gh t
0900111	1.7 149 955 7	1.1 602 948 89	- 0.1 034 181 9	0.5 646 374 76	0.3 646 619 26	1.8 996 369 89	- 1.1 317 953 09	- 1.2 516 642 26	- 0.5 601 746 86	0.3 612 965 23	2.5 496 751 2	- 1.6 465 224 26	- 2.7 931 819 74	- 3. 17 60 2
1001164	- 0.8 131 997 16	- 0.0 937 612 03	- 0.1 034 181 9	0.1 222 400 3	0.6 802 726 83	- 0.5 218 782 94	1.6 719 703 43	1.2 656 324 93	0.5 586 682 64	0.7 672 152 95	0.1 874 805 15	- 1.7 589 472 21	- 2.7 694 767 32	- 3. 24 73 5
104	0.2 806 612 82	1.1 602 948 89	- 1.4 866 364 84	0.4 323 650 2	0.1 063 550 15	- 0.5 218 782 94	- 1.1 317 953 09	- 0.7 329 280 28	- 1.3 283 815 72	- 0.7 162 965 49	- 1.0 495 476 46	- 0.9 223 105 19	0.4 928 855 5	- 0. 26 09 1
105	- 0.3 350 882 87	2.4 143 509 82	1.2 798 001 03	0.7 485 819 37	0.6 926 301 73	1.8 996 369 89	0.2 700 875 17	- 0.3 280 430 66	0.1 490 022 65	0.1 006 173 3	0.1 214 637 64	- 0.2 861 686 92	- 0.7 678 045 73	0. 83 29 41
107	0.7 515 285 99	- 0.0 937 612 03	- 0.1 034 181 9	0.7 622 532 26	0.7 990 427 97	- 0.5 218 782 94	0.2 700 875 17	- 0.2 724 469 21	0.0 219 799 65	- 1.0 970 216 6	- 0.7 404 215 92	0.7 475 617 78	1.3 123 341 3	1. 12 64 12
1-	0.6 428	- 0.0 937	- 0.1 034	0.3 637	0.2 222 734	- 0.5 218	- 1.1 317	- 0.3 751	NA	NA	NA	- 0.6 113	- 1.6 787	- 1. 18

1 0	669 1	612 03	181 9	351 49		782 94	953 09	789 27				962 01	797 52	58 7
1 - 1 1	0.2 806 612 82	- 0.0 937 612 03	- 0.1 034 181 9	1.0 292 535 02	0.7 997 565 4	- 0.5 218 782 94	0.2 700 875 17	- 0.7 184 246 86	NA	NA	NA	0.6 007 733 04	- 0.1 535 333 11	0. 71 38 99
1 - 1 8	- 0.4 437 499 75	- 0.0 937 612 03	- 0.1 034 181 9	0.3 713 090 43	0.4 441 826 52	- 0.5 218 782 94	1.6 719 703 43	0.5 977 535 96	- 1.1 077 007 69	0.1 222 387 56	- 1.0 600 264 95	- 0.4 452 041 49	1.1 232 306 12	0. 08 59 23
1 - 1 9	0.1 357 790 3	- 0.0 937 612 03	- 0.1 034 181 9	0.0 652 088 8	0.1 884 354 83	- 0.5 218 782 94	0.2 700 875 17	0.5 264 454 98	0.6 370 295 75	- 0.4 718 804 29	- 0.7 954 355 5	0.2 704 554 07	1.0 601 961 05	- 0. 20 75 5
1 - 2 3	0.6 428 669 1	1.1 602 948 89	- 1.4 866 364 84	0.3 909 136 72	0.0 879 923 49	1.8 996 369 89	- 1.1 317 953 09	- 0.0 138 039 9	- 0.6 156 392 74	- 1.8 274 498 35	- 0.5 910 979 89	0.9 065 972 35	1.2 177 823 71	1. 65 99 96
1 - 2 4	1.3 672 781 67	- 0.0 937 612 03	- 0.1 034 181 9	0.5 903 504 37	0.7 229 318 17	- 0.5 218 782 94	1.6 719 703 43	0.9 385 821 32	- 1.0 603 808 73	- 1.2 681 129 44	- 0.6 801 682 08	1.3 837 036 06	0.4 928 855 5	1. 15 30 91
1 - 2 5	- 0.8 059 556 04	- 0.0 937 612 03	- 1.4 866 364 84	0.4 352 086 48	0.4 420 738 65	- 0.5 218 782 94	0.2 700 875 17	- 0.5 286 726 29	NA	NA	NA	- 1.3 198 991 62	- 0.5 156 665 48	- 0. 42 09 8
1 - 2 6	- 0.9 508 378 55	- 0.0 937 612 03	1.2 798 001 03	0.4 473 760 96	0.7 438 899 13	1.8 996 369 89	0.2 700 875 17	NA	- 0.9 311 779 32	- 0.8 591 859 74	- 1.0 390 687 97	0.5 090 085 93	- 0.6 417 355 61	0. 29 93 57
1 - 3 1	- 1.1 681 612 32	- 0.0 937 612 03	- 0.1 034 181 9	0.2 556 499 37	0.3 580 468 24	- 0.5 218 782 94	0.2 700 875 17	- 0.1 987 216	- 1.0 758 634 19	- 1.3 104 157 34	- 0.9 107 028 93	- 1.3 198 991 62	0.1 146 785 13	1. 17 97 71
1	1.0 050	1.1 602	- 1.4	0.9 576	0.8 208	1.8 996	0.2 700	- 1.7	NA	NA	NA	- 1.3	0.5 452	0. 32

3 2	725 39	948 89	866 364 84	159 47	444 08	369 89	875 17	868 375 44				486 820 75	041 9	34 75
1 - 3 3	- 1.1 681 612 32	2.4 143 509 82	- 1.4 866 364 84	0.3 994 718 99	0.0 791 030 01	1.8 996 369 89	0.2 700 875 17	- 1.1 897 833	0.1 207 629 73	0.1 824 027 24	- 0.3 291 267 56	- 0.9 223 105 19	0.2 407 475 25	- 1. 63 22 2
1 - 3 6	- 1.1 681 612 32	- 2.6 018 733 88	2.6 630 183 97	0.4 678 283 44	0.7 879 473 34	- 0.5 218 782 94	0.2 700 875 17	0.0 369 577 07	NA	NA	NA	- 0.3 656 864 2	- 0.1 689 767 65	0. 53 94 7
1 - 3 7	NA	NA	NA	NA	NA	- 0.5 218 782 94	0.2 700 875 17	0.9 978 041 11	NA	NA	NA	NA	NA	N A
1 - 3 8	NA	NA	NA	NA	NA	- 0.5 218 782 94	NA	NA	NA	NA	NA	NA	NA	N A
1 - 3 9	- 0.0 815 443 47	1.1 602 948 89	- 0.1 034 181 9	0.5 061 626 39	0.4 373 372 05	- 0.5 218 782 94	- 1.1 317 953 09	0.0 405 835 42	- 1.5 515 701 12	- 0.7 087 760 53	0.4 096 321 2	- 0.3 656 864 2	- 0.1 689 767 65	0. 27 26 78
1 - 4 1	0.2 806 612 82	- 1.3 478 172 96	- 1.4 866 364 84	0.8 321 135 13	0.6 819 889 11	1.8 996 369 89	- 1.1 317 953 09	0.2 037 461 39	NA	1.1 628 873 92	NA	0.3 568 104 08	0.9 625 546 63	- 0. 09 45 4
1 - 4 4	1.1 137 342 27	1.1 602 948 89	- 0.1 034 181 9	0.2 990 426 09	0.3 082 470 14	- 0.5 218 782 94	- 1.1 317 953 09	- 0.3 256 258 42	0.4 095 887 87	- 0.3 844 546 63	- 0.0 671 555 24	- 0.5 247 218 77	- 0.9 569 080 91	0. 80 62 62
1 - 4 6	- 0.5 886 322 27	1.1 602 948 89	- 1.4 866 364 84	- 0.0 875 814 47	- 0.0 877 182 52	1.8 996 369 89	0.2 700 875 17	0.3 294 417 7	0.1 689 551 24	- 1.3 433 179 05	- 0.2 348 171 12	- 0.3 656 864 2	- 1.0 199 425 98	0. 85 96 2

1	1.2	1.1	-	0.7	0.4	-	1.6	0.8	0.1	-	-	-	-	-
4	223	602	0.1	536	720	0.5	719	104	829	0.0	0.2	0.6	1.5	0.
7	959	948	034	129	186	218	703	692	112	507	374	837	872	63
	16	89	181	71	37	782	43	78	22	326	368	573	531	44
			9			94				52	25	34	53	2
1	0.3	-	-	0.4	0.5	-	0.2	1.6	-	0.1	-	-	-	-
4	893	0.0	0.1	711	288	0.5	700	468	1.0	006	0.4	0.7	1.0	0.
8	229	937	034	914	585	218	875	286	765	173	784	632	829	31
	7	612	181	81	5	782	17	64	176	3	503	750	771	42
		03	9			94			12		59	63	04	6
1	-	-	-	1.1	1.0	-	-	-	NA	NA	NA	1.0	-	0.
5	0.2	1.3	1.4	279	009	0.5	1.1	0.4				791	0.6	46
1	264	478	866	602	023	218	317	621				507	378	88
	265	172	364	09	53	782	953	989				06	269	77
	98	96	84			94	09	79					25	
1	-	-	-	0.2	0.3	-	0.2	1.4	0.7	0.0	-	1.7	-	1.
5	1.6	0.0	0.1	899	560	0.5	700	268	110	639	1.1	812	0.8	17
3	752	937	034	648	353	218	875	613	623	549	700	922	308	97
	491	612	181	73	66	782	17	11	15	12	544	48	390	71
	12	03	9			94					13		79	
1	-	-	1.2	0.1	0.2	-	0.2	0.6	1.0	0.0	0.1	-	0.8	-
5	0.9	0.0	798	635	134	0.5	700	436	637	470	214	0.3	080	1.
4	508	937	001	601	813	218	875	808	808	337	637	656	580	70
	378	612	03	34	81	782	17	45	92	96	64	864	81	15
	55	03				94						2		8
1	-	1.1	-	-	-	1.8	-	NA	NA	NA	NA	-	-	-
5	0.5	602	1.4	0.3	0.4	996	1.1					0.8	0.4	0.
7	886	948	866	333	818	369	317					427	526	36
	322	89	364	365	667	89	953					927	320	76
	27		84	39	16		09					91	42	2
1	-	-	-	0.0	-	-	-	1.0	-	-	0.2	-	0.6	-
5	0.6	0.0	0.1	398	0.0	0.5	1.1	195	0.0	0.8	917	0.6	189	0.
9	972	937	034	076	693	218	317	591	032	093	450	042	545	74
	939	612	181	25	231	782	953	24	064	626	65	396	62	11
	15	03	9		43	94	09		31	88		06		3
1	-	-	-	0.4	0.4	-	0.2	1.4	NA	NA	NA	-	-	-
6	1.5	1.3	0.1	982	299	0.5	700	449				0.5	0.7	1.
0	303	478	034	606	077	218	875	904				140	040	37
	668	172	181	34	87	782	17	88				652	776	21
	61	96	9			94						49	8	5
1	1.8	-	-	-	-	-	-	0.4	NA	NA	NA	-	-	-
6	381	0.0	1.4	0.2	0.4	0.5	1.1	527				0.6	0.8	1.
1	454	937	866	861	686	218	317	201				042	308	32
	84							76						

		612 03	364 84	159 07	949 1	782 94	953 09					396 06	390 79	80 7
1	0.2	-	-	0.5	0.5	-	-	1.2	NA	NA	NA	-	-	-
-	806	1.3	1.4	518	428	0.5	1.1	165				1.3	0.6	1.
6	612	478	866	520	089	218	317	628				087	010	22
2	82	172	364	87	86	782	953	53				666	783	17
		96	84			94	09					8	04	8
1	0.6	-	1.2	0.2	0.3	-	-	0.4	NA	NA	NA	-	1.1	-
-	428	0.0	798	984	706	0.5	1.1	515				0.5	862	0.
6	669	937	001	957	671	218	317	115				247	651	74
7	1	612	03	57	01	782	953	64				218	18	11
		03				94	09					77		3
1	0.8	1.1	-	0.5	0.2	1.8	0.2	-	0.7	0.1	-	1.1	NA	N
-	601	602	1.4	101	505	996	700	0.0	662	513	0.2	451		A
7	902	948	866	273	635	369	875	005	325	806	557	504		
1	87	89	364	13	85	89	17	092	16	78	748	2		
A			84					6			11			
1	0.1	-	-	0.3	0.3	1.8	-	0.7	NA	NA	NA	-	-	-
-	357	0.0	0.1	771	273	996	1.1	790				1.6	1.1	1.
7	790	937	034	330	883	369	317	453				182	019	22
2	3	612	181	12	09	89	953	7				471	494	65
		03	9				09					74	97	3
1	2.2	-	-	0.1	0.2	-	0.2	-	0.0	-	-	-	0.4	-
-	003	0.0	0.1	758	026	0.5	700	0.1	507	0.0	0.4	0.7	928	0.
7	511	937	034	916	779	218	875	540	644	704	391	632	855	10
4	13	612	181	37	05	782	17	029	17	739	546	750	5	08
		03	9			94		62		54	74	63		3
1	1.9	1.1	-	0.1	-	-	-	-	0.7	0.9	0.2	-	0.0	-
-	468	602	1.4	041	0.1	0.5	1.1	1.1	947	053	105	1.0	516	0.
7	071	948	866	447	247	218	317	740	989	104	339	813	440	47
6	73	89	364	12	680	782	953	713	05	04	83	459	07	43
			84		13	94	09	46				76		4
1	-	1.1	-	0.5	0.4	1.8	0.2	-	-	-	-	0.1	0.1	1.
-	0.0	602	0.1	770	739	996	700	0.0	1.2	0.7	0.9	909	461	49
7	815	948	034	619	003	369	875	150	714	567	709	376	957	99
8	443	89	181	44	23	89	17	126	668	192	562	79	66	21
	47		9					02	59	15	76			
1	1.1	-	-	0.2	0.5	-	1.6	1.7	-	0.8	-	NA	1.5	1.
-	137	1.3	0.1	401	374	0.5	719	217	0.3	930	0.1		014	07
7	342	478	034	466	559	218	703	625	255	895	378		376	30
9	27	172	181	96	12	782	43	97	050	98	877		49	54
		96	9			94			75		56			
1	0.2	1.1	1.2	0.8	0.7	-	-	-	NA	NA	NA	-	-	-
	806	602	798	853	249	0.5	1.1	0.9				1.5	0.0	1.

8 1	612 82	948 89	001 03	768 56	432 75	218 782 94	317 953 09	214 714 74				584 523 47	113 904 99	06 12 8
1 - 8 2	1.7 294 837 96	1.1 602 948 89	- 0.1 034 181 9	0.2 663 408 85	0.1 075 554 01	1.8 996 369 89	- 1.1 317 953 09	- 0.0 536 881 8	NA	NA	NA	0.8 270 795 07	- 0.5 156 665 48	0. 43 27 53
1 - 8 5	1.1 137 342 27	- 0.0 937 612 03	1.2 798 001 03	0.4 435 754 77	0.4 954 099 48	- 0.5 218 782 94	- 1.1 317 953 09	NA	NA	NA	NA	- 0.6 042 396 06	0.1 777 130 19	0. 77 95 83
1 - 8 7	1.9 468 071 73	- 1.3 478 172 96	- 0.1 034 181 9	- 0.0 170 922 8	- 0.0 903 461 24	- 0.5 218 782 94	- 1.1 317 953 09	- 0.5 093 348 4	- 1.2 298 166 28	- 1.3 357 974 09	- 0.5 282 248 93	- 0.1 271 332 35	0.5 559 200 56	0. 61 95 07
1 - 8 8	0.7 515 285 99	- 0.0 937 612 03	1.2 798 001 03	0.2 995 621 18	0.5 965 019 41	- 0.5 218 782 94	- 1.1 317 953 09	- 0.6 362 390 82	- 0.6 512 927 43	- 0.5 762 273 11	- 0.0 383 386 88	- 0.0 476 155 06	- 0.2 950 457 77	0. 61 95 07
1 - 8 9	- 0.3 350 882 87	- 1.3 478 172 96	1.2 798 001 03	0.3 514 036 46	0.4 987 191 21	- 0.5 218 782 94	1.6 719 703 43	0.7 597 075 81	NA	NA	NA	- 1.2 403 814 33	- 0.3 895 975 36	0. 37 93 94
1 - 9 1	0.2 806 612 82	- 0.0 937 612 03	- 0.1 034 181 9	0.6 259 504 74	0.5 496 219 89	1.8 996 369 89	0.2 700 875 17	- 0.2 071 818 83	NA	NA	NA	0.8 534 768 88	0.6 428 456 33	1. 27 51 23
1 - 9 2	- 0.6 972 939 15	1.1 602 948 89	1.2 798 001 03	1.0 524 400 08	0.8 982 855 45	- 0.5 218 782 94	- 1.1 317 953 09	NA	NA	NA	NA	0.2 704 554 07	1.0 917 133 59	1. 28 64 87
2 - 0 2	2.0 916 894 24	1.1 602 948 89	- 0.1 034 181 9	0.5 069 555 73	0.3 047 431 83	- 0.5 218 782 94	1.6 719 703 43	0.9 023 237 77	- 0.9 470 966 07	0.1 617 213 6	- 0.1 614 651 67	0.7 475 617 78	0.5 559 200 56	0. 77 95 83

2 - 0 3	- 0.0 815 443 47	2.4 143 509 82	1.2 798 001 03	0.1 331 825 3	0.0 869 541 77	- 0.5 218 782 94	1.6 719 204 43	0.5 933 818 160	0.3 0.0 0.8 - 1.5 -	0.0 818 314 05	0.8 314 058 05	- 0.0 476 155 06	1.5 014 376 49	- 0. 10 08 3
2 - 0 4	0.1 357 790 3	2.4 143 509 82	- 1.4 866 364 84	0.2 435 371 75	- 0.1 393 348 63	1.8 996 369 89	0.2 700 875 17	NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA	- 0.8 030 339 27	1.5 014 376 49	- 0. 10 08 3
2 - 0 7	0.2 806 612 82	NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA	- 0.5 218 782 94	NA NA NA NA	1.9 538 160 68	NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA	N A A A
2 - 0 9	1.1 137 342 27	- 0.0 937 612 03	- 1.4 866 364 84	0.1 734 581 47	0.0 818 282 03	- 0.5 218 782 94	1.6 719 724 43	0.9 724 232 63	0.7 394 106 4	2.9 725 067 45	0.8 890 394 76	0.9 065 972 35	1.0 601 961 05	1. 23 31 29
2 - 1 0	1.1 137 342 27	- 0.0 937 612 03	1.2 798 001 03	0.8 230 904 62	0.8 523 139 94	- 0.5 218 782 94	- 1.1 317 953 09	- 0.9 202 628 62	NA NA NA NA	NA NA NA NA	NA NA NA NA	- 0.2 125 365 27	1.3 095 596 19	0. 07 49 32
2 - 1 0 0	1.5 846 015 44	- 0.0 937 612 03	- 1.4 866 364 84	0.9 114 069 9	0.5 940 687 25	- 0.5 218 782 94	- 1.1 317 953 09	0.2 242 925 41	NA NA NA NA	NA NA NA NA	NA NA NA NA	0.3 897 32	- 0.1 240 957	0. 45 61 23
2 - 1 0 8	0.0 271 173 42	- 0.0 937 612 03	- 1.4 866 364 84	0.3 972 298 07	0.1 172 558 2	1.8 996 369 89	0.2 700 875 17	0.4 104 187 62	- 0.0 246 857 39	- 0.8 920 881 44	- 0.6 696 893 59	0.1 909 376 79	1.3 123 341 3	- 1. 32 80 7
2 - 1 2 7	0.0 271 173 42	- 1.3 478 172 96	- 0.1 034 181 9	0.4 292 206 24	0.7 186 169 15	- 0.5 218 782 94	0.2 700 875 17	1.1 972 250 63	NA NA NA NA	NA NA NA NA	NA NA NA NA	0.7 475 617 78	1.1 862 651 18	1. 28 64 87
2 - 1 4	- 0.5 886	- 1.3 478	- 0.1 034	0.2 367 015 31	0.2 694 453 37	- 0.5 218	0.2 700 875 17	- 1.3 710	NA NA NA NA	NA NA NA NA	NA NA NA NA	0.6 282 851 85	1.4 384 031 42	1. 07 30 54

	322 27	172 96	181 9			782 94		750 74						
2	-	-	-	0.6	0.9	-	-	-	NA	NA	3.6	0.7	2.8	0.
-	2.2	0.0	0.1	729	720	0.5	1.1	2.4			528	017	991	14
2	547	937	034	797	281	218	317	600			359	608	012	85
0	781	612	181	08	96	782	953	343			81	19	57	12
	18	03	9			94	09	33						
2	-	-	1.2	0.4	0.5	-	0.2	NA	NA	NA	NA	-	-	-
-	1.0	0.0	798	039	648	0.5	700					0.5	0.4	0.
2	594	937	001	287	701	218	875					843	673	42
1	995	612	03	39	39	782	17					601	831	04
	44	03				94						73	09	
2	0.2	-	-	0.2	0.3	-	1.6	0.2	0.5	1.4	-	0.9	0.1	0.
-	806	1.3	0.1	369	206	0.5	719	532	979	618	0.2	065	461	96
2	612	478	034	476	401	218	703	992	961	271	033	972	957	63
2	82	172	181	14	91	782	43	24	13	09	805	35	66	37
		96	9			94					65			
2	-	-	-	0.5	0.6	-	-	0.8	1.7	-	1.0	0.6	0.5	1.
-	0.9	0.0	1.4	130	417	0.5	1.1	068	794	0.0	488	680	559	12
2	508	937	866	803	597	218	317	434	670	450	419	440	200	64
4	378	612	364	11	48	782	953	42	55	922	28	5	56	12
	55	03	84			94	09			8				
2	0.0	-	1.2	1.2	1.2	-	0.2	0.9	0.7	2.6	2.8	1.6	0.7	1.
-	271	0.0	798	171	469	0.5	700	301	931	585	328	222	135	17
2	173	937	001	243	166	218	875	218	634	260	660	567	063	97
5	42	612	03	57	59	782	17	49	24	37	22	91	22	71
		03				94								
2	-	-	-	0.1	0.1	-	-	0.8	0.3	0.5	0.6	0.8	-	1.
-	2.2	0.0	0.1	640	886	0.5	1.1	721	286	180	951	270	0.1	28
2	547	937	034	249	950	218	317	084	870	048	807	795	374	64
7	781	612	181	58	26	782	953	81	3	59	64	07	595	87
	18	03	9			94	09						11	
2	-	-	1.2	0.5	0.9	-	-	0.2	-	-	-	0.3	0.3	0.
-	1.3	0.0	798	413	094	0.5	1.1	786	0.6	0.5	0.5	499	037	48
2	130	937	001	798	783	218	317	800	494	113	622	731	820	61
9	434	612	03	79	37	782	953	73	391	630	811	36	32	11
	84	03				94	09		99	33	53			
2	-	-	-	0.9	0.5	-	1.6	-	NA	NA	NA	0.5	1.1	1.
-	0.8	0.0	0.1	516	418	0.5	719	0.2				859	907	47
3	059	937	034	005	356	218	703	446				842	395	75
1	556	612	181	8	99	782	43	488				58	75	63
	04	03	9			94		49						
2	0.3	1.1	1.2	0.3	0.4	-	1.6	0.4	0.6	1.4	-	0.1	0.1	0.
	893	602	798	382	588	0.5	719	406	348	505	0.0	909	146	69

3	229	948	001	245	143	218	703	340	489	463	540	376	785	95
4	7	89	03	23	87	782	43	58	35	65	569	79	13	45
						94					62			
2	-	1.1	1.2	0.1	0.2	-	0.2	-	-	-	-	1.1	-	0.
-	0.8	602	798	849	624	0.5	700	1.2	1.1	0.2	0.2	451	0.8	59
3	059	948	001	420	052	218	875	296	456	641	505	504	938	28
8	556	89	03	3	34	782	17	674	439	267	353	2	735	28
	04					94		9	11	27	86		85	
2	-	-	-	-	-	-	0.2	-	NA	NA	NA	-	-	-
-	3.2	0.0	0.1	0.0	0.1	0.5	700	1.0				1.8	0.2	0.
3	327	937	034	202	666	218	875	870				765	635	63
9	333	612	181	366	193	782	17	512				232	285	44
	14	03	9	77	19	94		94				61	24	2
2	0.7	-	1.2	-	-	1.8	0.2	1.9	NA	NA	NA	-	-	-
-	515	0.0	798	1.9	1.8	996	700	634				1.2	1.3	1.
4	285	937	001	039	995	369	875	849				777	724	50
0	99	612	03	215	553	89	17	63				547	320	43
		03		73	82							66	52	7
2	0.2	1.1	1.2	-	-	-	1.6	0.4	NA	NA	NA	-	-	-
-	806	602	798	1.9	1.9	0.5	719	974				0.0	0.6	0.
4	612	948	001	896	476	218	703	388				395	867	67
1	82	89	03	132	357	782	43	14				072	431	67
				13	2	94						03	91	3
2	-	-	-	0.1	0.2	-	0.2	NA	NA	NA	NA	0.1	0.1	0.
-	0.8	0.0	0.1	569	052	0.5	700					909	146	43
4	059	937	034	705	408	218	875					376	785	27
3	556	612	181	73	92	782	17					79	13	53
	04	03	9			94								
2	-	-	1.2	0.2	0.5	-	1.6	NA	3.9	-	1.4	0.0	1.2	0.
-	0.5	0.0	798	993	359	0.5	719		883	0.9	208	319	492	91
4	886	937	001	707	959	218	703		466	719	410	022	996	29
6	322	612	03	2	82	782	43		97	934	78	22	24	79
	27	03				94				14				
2	-	-	-	0.5	0.4	-	0.2	-	0.6	NA	NA	-	0.7	0.
-	0.9	0.0	0.1	789	863	0.5	700	0.5	085			0.7	295	20
5	508	937	034	212	583	218	875	830	722			368	180	89
2	378	612	181	39	87	782	17	601	19			776	79	67
	55	03	9			94		62				81		
2	1.2	-	-	1.1	1.0	-	0.2	NA	NA	NA	NA	-	-	0.
-	223	1.3	0.1	192	153	0.5	700					1.8	0.3	43
6	959	478	034	926	394	218	875					765	895	27
3	16	172	181	12	31	782	17					232	975	53
		96	9			94						61	36	

2 - 6 4	- 1.0 594 995 44	- 1.3 478 172 96	- 0.1 034 181 9	0.2 058 317 6	0.6 815 671 54	- 0.5 218 782 94	0.2 700 875 17	NA	- 1.7 638 554 5	0.9 306 920 78	- 0.4 024 787 01	0.3 499 731 36	- 0.1 374 595 11	- 0. 31 42 6
2 - 6 9	NA	- 0.0 937 612 03	- 1.4 866 364 84	0.8 230 904 62	0.8 857 301 54	1.8 996 369 89	0.2 700 875 17	1.3 470 929 3	NA	NA	NA	- 1.6 774 096 17	- 0.3 007 809 24	- 0. 97 92 2
2 - 7 0	0.7 515 285 99	2.4 143 509 82	- 0.1 034 181 9	1.2 086 208 15	0.9 742 991 97	- 0.5 218 782 94	- 1.1 317 953 09	0.7 282 836 73	NA	NA	NA	0.7 491 521 33	1.1 914 964 85	- 0. 27 45 1
2 - 8 0	- 0.0 815 443 47	- 0.0 937 612 03	- 0.1 034 181 9	1.4 596 256 83	1.1 955 595 91	- 0.5 218 782 94	0.2 700 875 17	0.0 272 888 12	NA	NA	NA	- 0.3 531 201 15	0.6 875 356 09	- 0. 61 85 1
2 - 8 2	0.7 515 285 99	- 0.0 937 612 03	1.2 798 001 03	0.3 167 059 14	0.3 491 250 34	- 0.5 218 782 94	0.2 700 875 17	1.1 488 805 9	NA	NA	NA	- 0.9 951 475 06	- 0.3 871 381 98	- 1. 05 29
2 - 9 4	- 0.5 886 322 27	- 1.3 478 172 96	- 1.4 866 364 84	0.3 085 031 41	0.6 210 611 95	- 0.5 218 782 94	- 1.1 317 953 09	1.2 346 920 3	0.3 224 722 05	0.1 372 797 48	- 0.9 630 971 39	- 1.8 765 232 61	0.1 777 130 19	1. 12 64 12
2 - 9 8	- 0.3 350 882 87	- 1.3 478 172 96	1.2 798 001 03	0.1 878 950 29	0.6 193 741 66	- 0.5 218 782 94	- 1.1 317 953 09	NA	1.3 406 131 84	3.0 695 9E- 05	- 0.3 762 815 78	0.1 909 376 79	0.9 341 270 93	0. 80 62 62
3 - 0 1	- 0.4 437 499 75	- 1.3 478 172 96	- 0.1 034 181 9	1.0 653 457 05	0.9 071 424 5	- 0.5 218 782 94	- 1.1 317 953 09	0.6 303 861 15	NA	NA	NA	1.2 773 063 81	- 1.3 164 579 07	0. 50 19 05
3 - 1 0	- 0.4 437	- 0.0 937	1.2 798 001 03	0.6 057 169 66	0.9 120 088 81	- 0.5 218	1.6 719 703 43	0.3 644 915 13	NA	NA	NA	0.0 716 610 86	- 0.5 599	- 0. 01

	499 75	612 03				782 94							793 1	16 2
3 - 1 0 0	0.0 271 173 42	- 1.3 478 172 96	- 0.1 034 181 9	0.6 327 861 18	0.7 497 945 16	- 0.5 218 782 94	1.6 719 703 43	0.1 408 983 24	NA	NA	NA	0.4 221 777 38	- 0.9 496 591 23	- 0. 47 25 8
3 - 1 0 2	- 0.5 886 322 27	NA	NA	NA	NA	- 0.5 218 782 94	NA	- 3.0 159 957 74	NA	NA	NA	NA	NA	NA
3 - 1 5	- 0.8 059 556 04	- 0.0 937 612 03	2.6 630 183 97	0.2 104 799 98	0.4 413 925 65	- 0.5 218 782 94	0.2 700 875 17	- 2.1 349 177 51	NA	NA	NA	0.9 861 149 63	1.3 123 341 3	- 0. 15 41 9
3 - 2 0	- 0.2 264 265 98	- 0.0 937 612 03	- 0.1 034 181 9	- 2.0 217 134	- 2.0 149 546 82	1.8 996 369 89	0.2 700 875 17	0.4 394 254 46	NA	NA	NA	1.3 396 495 32	0.1 828 178 22	- 0. 39 55 3
3 - 2 1	0.2 806 612 82	1.1 602 948 89	- 1.4 866 364 84	- 2.0 561 103 63	- 2.0 668 308 36	1.8 996 369 89	0.2 700 875 17	- 0.3 038 708 29	NA	NA	NA	- 0.1 441 512 81	- 0.2 316 340 56	- 1. 31 48 4
3 - 3 0	- 0.9 508 378 55	1.1 602 948 89	- 0.1 034 181 9	- 2.0 158 894 31	- 2.0 316 952 04	1.8 996 369 89	- 1.1 317 953 09	- 0.9 311 403 68	NA	NA	NA	0.3 461 537 8	- 2.2 883 234 27	- 2. 23 90 6
3 - 3 3	0.4 979 846 59	- 0.0 937 612 03	- 0.1 034 181 9	- 1.9 711 569 73	- 1.9 507 502 36	- 0.5 218 782 94	- 1.1 317 953 09	0.1 336 466 53	NA	NA	NA	2.5 084 036 09	0.4 513 448 18	0. 68 22 56
3 - 4 0	- 0.3 350 882 87	- 0.0 937 612 03	- 0.1 034 181 9	- 1.8 886 917 57	- 1.9 102 615 3	- 0.5 218 782 94	1.6 719 703 43	- 1.0 121 173 61	NA	NA	NA	- 0.3 278 372 34	0.4 162 986 25	0. 23 16 44
3	- 0.4	- 1.3	1.2 798	- 1.9	- 1.9	- 0.5	0.2 700	- 1.0	NA	NA	NA	0.3 391	0.8 987	- 0.

5075	43749975	47817296	00103	81027643	38778816	21878294	87517	72547952				59977	65728	78825
354	-0.950837855	-1.347817296	-0.10341819	-0.090671158	-0.063263268	-0.521888794	0.270087517	0.167487785	0.17037254	-0.565886629	0.5432374	2.258398619	-0.263528524	0.779583
360	0.38932297	-1.347817296	-0.10341819	-1.970719491	-1.959412483	-0.521878294	1.131795309	93599228	NA	NA	NA	-0.498637558	-0.627867969	0.93541
370	-0.588632227	0.093761203	0.10341819	1.913792244	1.954935366	0.521878294	1.131795309	0.081486252	NA	NA	NA	0.460346247	-0.660077609	-0.69076
380	0.751528599	-0.093761203	-1.486636484	2.013073145	1.992439328	0.521878294	0.270087517	-0.792150008	NA	NA	NA	0.068956231	0.72504114	0.428325
387	-1.168161232	0.093761203	1.279800103	0.269375912	0.339813929	-0.521878294	0.270087517	-1.505230987	-0.48305634	1.310477126	0.451547517	0.986114963	0.555920056	1.126412
394	-0.950837855	-1.347817296	1.279800103	0.651871238	0.93449192	-0.521878294	0.270087517	0.748830075	-0.273060675	-1.180687178	-0.72732303	3.292129089	0.68198969	0.379394
398	-0.697293915	0.093761203	-0.10341819	0.659663873	0.264449135	-0.521878294	0.270087517	-0.207181883	-0.16904413	1.192029314	0.545857161	1.70177452	1.375368636	1.233129
401	-0.805955604	-0.093761203	-0.10341819	-1.942474608	-1.91026153	1.899636989	1.671970343	0.475683801	NA	NA	NA	-0.248476036	-0.347741631	-0.26422

4 0 4	1.1 137 342 27	NA	NA	NA	NA	- 0.5 218 782 94	0.2 700 875 17 041 21	- 0.7 015	NA	NA	NA	NA	NA	NA	N A
4 1 0	0.3 893 229 7	- 0.0 937 612 03	- 0.1 034 181 9	- 2.0 218 227 7	- 2.0 286 131 31	- 0.5 218 782 94	- 1.1 317 886 953 85 09	0.2 798	NA	NA	NA	- 0.5 931 071 24	- 0.9 058 501 41	- 0. 60 66 2	
4 1 0 0	0.2 806 612 82 03	- 0.0 937 612 03	- 0.1 034 181 9	- 1.9 754 224 15	- 1.9 424 448 6	- 0.5 218 782 94	1.6 719 703 43 056 63	- 0.4 912	NA	NA	NA	- 0.2 807 589 82	- 1.0 158 453 55	- 0. 59 71 7	
4 1 0 2	1.4 759 398 56	NA	NA	NA	NA	- 0.5 218 782 94	NA	1.9 695 280 22	NA	NA	NA	NA	NA	N A	
4 1 2	- 0.5 886 322 27	- 0.0 937 612 03	- 0.1 034 181 9	- 1.9 272 447 92	- 1.9 485 765 63	1.8 996 369 89	0.2 700 875 17	NA	NA	NA	NA	- 0.1 427 174 57	- 1.5 457 769 44	- 0. 25 33 3	
4 1 2 6	- 0.4 437 499 75	NA	NA	NA	NA	- 0.5 218 782 94	NA	0.2 097 891 99	NA	NA	NA	NA	NA	N A	
4 2 1	0.6 428 669 1	- 0.0 937 612 03	- 0.1 034 181 9	- 2.0 413 180 28	- 2.0 374 375 93	1.8 996 369 89	- 1.1 317 953 09	- 1.7 856 289 32	NA	NA	NA	1.3 121 376 5	- 0.5 856 968 92	0. 88 18 71	
4 3 0	- 1.1 681 612 32	- 0.0 937 612 03	- 0.1 034 181 9	- 1.9 057 261 83	- 1.8 865 782 33	- 0.5 218 782 94	1.6 719 703 43 057 595 2	- 0.9 057	NA	NA	NA	1.3 196 135 69	- 1.6 845 794 23	- 1. 16 02 1	
4 4 0	- 0.0 815	- 0.0 937	- 0.1 034	- 1.9 787	- 1.9 743	- 0.5 218	- 1.1 317	0.2 907 661 91	NA	NA	NA	- 0.4 967	- 1.6 478	- 1. 39	

	443 47	612 03	181 9	855 52	362 05	782 94	953 09					341 41	928 44	87 2
4	-	1.1	-	-	-	-	0.2	-	NA	NA	NA	0.5	-	-
-	0.0	602	0.1	1.9	1.9	0.5	700	0.4				983	1.5	1.
5	815	948	034	200	741	218	875	416				877	800	14
2	443	89	181	536	415	782	17	525				72	041	91
	47		9	94	47	94		77					85	1
4	0.3	-	-	0.0	0.2	-	0.2	-	0.3	-	-	-	-	0.
-	893	1.3	0.1	944	764	0.5	700	1.6	352	0.4	1.2	1.0	0.3	43
5	229	478	034	107	205	218	875	043	289	775	198	813	265	27
5	7	172	181	54	55	782	17	371	51	208	289	459	630	53
		96	9			94		57		01	47	76	3	
4	-	-	1.2	0.2	0.1	-	-	-	0.5	0.7	0.5	0.1	0.4	0.
-	1.6	0.0	798	041	967	0.5	1.1	1.3	765	614	406	909	298	59
6	752	937	001	912	408	218	317	698	168	809	177	376	510	28
6	491	612	03	05	59	782	953	664	06	17	36	79	44	28
	12	03				94	09	63						
4	1.0	-	-	-	-	-	-	-	NA	NA	NA	-	-	-
-	050	1.3	0.1	2.0	2.0	0.5	1.1	1.8				0.8	0.3	1.
8	725	478	034	092	086	218	317	158				971	655	57
0	39	172	181	725	932	782	953	442				841	823	67
		96	9	27	07	94	09	28				69	82	2
4	1.1	NA	NA	NA	NA	-	0.2	-	NA	NA	NA	NA	NA	N
-	137					0.5	700	0.2						A
8	342					218	875	809						
4	27					782	17	072						
						94		04						
4	1.3	NA	NA	NA	NA	1.8	-	-	NA	NA	NA	NA	NA	N
-	672					996	1.1	0.8						A
9	781					369	317	598						
5	67					89	953	322						
							09	7						

APPENDIX E

Flower Color Morphometric Data

Sample	Hex	R	G	B	H	S	V	Freq	Dens	HScaled	HBin
1_1 0	#984899	0.59 607 8	0.28 235 3	0.6	0.83 127 6	0.52 941 2	0.6	107 649	0.119767	299	295
1_1 0	#7b1d66	0.48 235 3	0.11 372 5	0.4	0.87 056 7	0.76 422 8	0.48 235 3	107 791	0.119925	313	310
1_1 0	#6c2e56	0.42 352 9	0.18 039 2	0.33 725 5	0.89 247 3	0.57 407 4	0.42 352 9	852 69	0.094868	321	320
1_1 0	#87347f	0.52 941 2	0.20 392 2	0.49 803 9	0.84 939 8	0.61 481 5	0.52 941 2	153 474	0.170751	305	305
1_1 0	#5c1340	0.36 078 4	0.07 451	0.25 098	0.89 726	0.79 347 8	0.36 078 4	171 102	0.190363	323	320
1_1 0	#a562aa	0.64 705 9	0.38 431 4	0.66 666 7	0.82 175 9	0.42 352 9	0.66 666 7	415 38	0.046214	295	295
1_1 0	#8c4e84	0.54 902	0.30 588 2	0.51 764 7	0.85 483 9	0.44 285 7	0.54 902	708 60	0.078837	307	305
1_1 0	#3b0922	0.23 137 3	0.03 529 4	0.13 333 3	0.91 666 7	0.84 745 8	0.23 137 3	126 310	0.140529	330	330
1_1 0	#986694	0.59 607 8	0.4	0.58 039 2	0.84 666 7	0.32 894 7	0.59 607 8	348 27	0.038747	304	300
1_1 1	#570936	0.34 117 6	0.03 529 4	0.21 176 5	0.90 384 6	0.89 655 2	0.34 117 6	713 726	0.10034	325	325
1_1 1	#7a236b	0.47 843 1	0.13 725 5	0.41 960 8	0.86 206 9	0.71 311 5	0.47 843 1	103 995 6	0.146204	310	310

1_1 1	#69 365 9	0.41 176 5	0.21 176 5	0.34 902	0.88 562 1	0.48 571 4	0.41 176 5	273 147	0.038401	318	315
1_1 1	#a3 3b9 d	0.63 921 6	0.23 137 3	0.61 568 6	0.84 294 9	0.63 803 7	0.63 921 6	115 275 6	0.162062	303	300
1_1 1	#8f 137 e	0.56 078 4	0.07 451	0.49 411 8	0.85 618 3	0.86 713 3	0.56 078 4	878 211	0.123465	308	305
1_1 1	#b0 60b 0	0.69 019 6	0.37 647 1	0.69 019 6	0.83 333 3	0.45 454 5	0.69 019 6	607 644	0.085427	300	300
1_1 1	#39 071 e	0.22 352 9	0.02 745 1	0.11 764 7	0.92 333 3	0.87 719 3	0.22 352 9	439 895	0.061843	332	330
1_1 1	#6e 0b5 4	0.43 137 3	0.04 313 7	0.32 941 2	0.87 710 4	0.9 137 3	0.43 137 3	950 195	0.133585	315	315
1_1 1	#8c 3a8 4	0.54 902	0.22 745 1	0.51 764 7	0.84 959 3	0.58 571 4	0.54 902	105 751 2	0.148672	305	305
1_1 8	#bc 2a8 1	0.73 725 5	0.16 470 6	0.50 588 2	0.90 068 5	0.77 659 6	0.73 725 5	275 669	0.154578	324	320
1_1 8	#37 071 4	0.21 568 6	0.02 745 1	0.07 843 1	0.95 486 1	0.87 272 7	0.21 568 6	135 409	0.075929	343	340
1_1 8	#9e 276 9	0.61 960 8	0.15 294 1	0.41 176 5	0.90 756 3	0.75 316 5	0.61 960 8	255 930	0.14351	326	325
1_1 8	#d2 419 5	0.82 352 9	0.25 490 2	0.58 431 4	0.90 344 8	0.69 047 6	0.82 352 9	100 284	0.056233	325	325
1_1 8	#6a 082 9	0.41 568 6	0.03 137 3	0.16 078 4	0.94 387 8	0.92 452 8	0.41 568 6	238 277	0.133611	339	335
1_1 8	#91 054 7	0.56 862 7	0.01 960 8	0.27 843 1	0.92 142 9	0.96 551 7	0.56 862 7	301 412	0.169013	331	330
1_1 8	#ba 4a8 b	0.72 941 2	0.29 019 6	0.54 509 8	0.90 327 4	0.60 215 1	0.72 941 2	134 202	0.075252	325	325

1_1 8	#b3 056 a	0.70 196 1	0.01 960 8	0.41 568 6	0.90 325 7	0.97 206 7	0.70 196 1	308 036	0.172727	325	325
1_1 8	#d0 79a 4	0.81 568 6	0.47 451 6	0.64 313 7	0.91 762 5	0.41 826 9	0.81 568 6	341 46	0.019147	330	330
1_1 9	#c1 3b9 1	0.75 686 3	0.23 137 3	0.56 862 7	0.89 303 5	0.69 430 1	0.75 686 3	118 020	0.134339	321	320
1_1 9	#7d 033 a	0.49 019 6	0.01 176 5	0.22 745 1	0.92 486 3	0.97 6	0.49 019 6	157 327	0.179081	332	330
1_1 9	#65 274 0	0.39 607 8	0.15 294 1	0.25 098	0.93 279 6	0.61 386 1	0.39 607 8	395 49	0.045018	335	335
1_1 9	#4d 071 c	0.30 196 1	0.02 745 1	0.10 980 4	0.95	0.90 909 1	0.30 196 1	124 920	0.142193	342	340
1_1 9	#93 325 f	0.57 647 1	0.19 607 8	0.37 254 9	0.92 268	0.65 986 4	0.57 647 1	472 83	0.053821	332	330
1_1 9	#cc 79b 0	0.8	0.47 451	0.69 019 6	0.88 955 8	0.40 686 3	0.8	557 55	0.063464	320	320
1_1 9	#b0 197 a	0.69 019 6	0.09 803 9	0.47 843 1	0.89 293 6	0.85 795 5	0.69 019 6	151 207	0.172115	321	320
1_1 9	#af 538 5	0.68 627 5	0.32 549	0.52 156 9	0.90 942	0.52 571 4	0.68 627 5	355 65	0.040483	327	325
1_1 9	#9a 025 9	0.60 392 2	0.00 784 3	0.34 902	0.90 460 5	0.98 701 3	0.60 392 2	148 899	0.169487	325	325
1_2 3	#fbf bfb	0.98 431 4	0.98 431 4	0.98 431 4	0	0	0.98 431 4	178 530	0.002793	0	0
1_2 3	#3d 062 5	0.23 921 6	0.02 352 9	0.14 509 8	0.90 606 1	0.90 163 9	0.23 921 6	928 372	0.014522	326	325
1_2 3	#b0 84b 9	0.69 019 6	0.51 764 7	0.72 549	0.80 503 1	0.28 648 6	0.72 549	169 89	0.000266	289	285

1_2 3	#86 318 2	0.52 549	0.19 215 7	0.50 980 4	0.84 117 6	0.63 432 8	0.52 549	839 098	0.013125	302	300
1_2 3	#94 4a9 9	0.58 039 2	0.29 019 6	0.6	0.82 278 5	0.51 634	0.6	397 143	0.006212	296	295
1_2 3	#a3 65a d	0.63 921 6	0.39 607 8	0.67 843 1	0.81 018 5	0.41 618 5	0.67 843 1	114 387	0.001789	291	290
1_2 3	#75 1f6 8	0.45 882 4	0.12 156 9	0.40 784 3	0.85 852 7	0.73 504 3	0.45 882 4	133 206 3	0.020836	309	305
1_2 3	#60 0a4 a	0.37 647 1	0.03 921 6	0.29 019 6	0.87 596 9	0.89 583 3	0.37 647 1	146 423 1	0.022904	315	315
1_2 3	#db dbd b	0.85 882 4	0.85 882 4	0.85 882 4	0	0	0.85 882 4	586 589 46	0.917553	0	0
1_2 4	#70 295 7	0.43 921 6	0.16 078 4	0.34 117 6	0.89 201 9	0.63 392 9	0.43 921 6	463 629	0.11104	321	320
1_2 4	#5a 083 a	0.35 294 1	0.03 137 3	0.22 745 1	0.89 837 4	0.91 111 1	0.35 294 1	753 439	0.18045	323	320
1_2 4	#3a 081 e	0.22 745 1	0.03 137 3	0.11 764 7	0.92 666 7	0.86 206 9	0.22 745 1	476 812	0.114197	333	330
1_2 4	#9b 469 7	0.60 784 3	0.27 451 7	0.59 215 7	0.84 117 6	0.54 838 7	0.60 784 3	244 866	0.058646	302	300
1_2 4	#91 4c7 8	0.56 862 7	0.29 803 9	0.47 058 8	0.89 372	0.47 586 2	0.56 862 7	190 908	0.045723	321	320
1_2 4	#71 045 a	0.44 313 7	0.01 568 6	0.35 294 1	0.86 850 2	0.96 460 2	0.44 313 7	672 595	0.161087	312	310
1_2 4	#81 187 2	0.50 588 2	0.09 411 8	0.44 705 9	0.85 714 3	0.81 395 3	0.50 588 2	687 091	0.164559	308	305
1_2 4	#aa 6aa 3	0.66 666 7	0.41 568 6	0.63 921 6	0.85 156 3	0.37 647 1	0.66 666 7	101 052	0.024202	306	305

1_2 4	#8a 308 1	0.54 117 6	0.18 823 5	0.50 588 2	0.85	0.65 217 4	0.54 117 6	584 952	0.140097	306	305
1_2 5	#60 0f3 a	0.37 647 1	0.05 882 4	0.22 745 1	0.91 152 3	0.84 375	0.37 647 1	267 21	0.071897	328	325
1_2 5	#78 1c5 e	0.47 058 8	0.10 980 4	0.36 862 7	0.88 043 5	0.76 666 7	0.47 058 8	292 66	0.078744	316	315
1_2 5	#a3 64a 3	0.63 921 6	0.39 215 7	0.63 921 6	0.83 333 3	0.38 650 3	0.63 921 6	394 71	0.106202	300	300
1_2 5	#7e 396 6	0.49 411 8	0.22 352 9	0.4	0.89 130 4	0.54 761 9	0.49 411 8	281 91	0.075852	320	320
1_2 5	#83 277 7	0.51 372 5	0.15 294 1	0.46 666 7	0.85 507 2	0.70 229	0.51 372 5	379 68	0.102158	307	305
1_2 5	#8d 398 6	0.55 294 1	0.22 352 9	0.52 549	0.84 722 2	0.59 574 5	0.55 294 1	702 18	0.188931	305	305
1_2 5	#65 2b4 a	0.39 607 8	0.16 862 7	0.29 019 6	0.91 092	0.57 425 7	0.39 607 8	209 01	0.056237	327	325
1_2 5	#3f 0e2 2	0.24 705 9	0.05 490 2	0.13 333 3	0.93 197 3	0.77 777 8	0.24 705 9	292 05	0.07858	335	335
1_2 5	#98 489 7	0.59 607 8	0.28 235 3	0.59 215 7	0.83 541 7	0.52 631 6	0.59 607 8	897 18	0.241399	300	300
1_2 6	#a2 136 c	0.63 529 4	0.07 451	0.42 352 9	0.89 627	0.88 271 6	0.63 529 4	183 114 0	0.183834	322	320
1_2 6	#95 607 d	0.58 431 4	0.37 647 1	0.49 019 6	0.90 880 5	0.35 570 5	0.58 431 4	246 990	0.024796	327	325
1_2 6	#be 549 8	0.74 509 8	0.32 941 2	0.59 607 8	0.89 308 2	0.55 789 5	0.74 509 8	588 336	0.059065	321	320
1_2 6	#6a 053 1	0.41 568 6	0.01 960 8	0.19 215 7	0.92 739 3	0.95 283	0.41 568 6	183 666 5	0.184389	333	330

1_2 6	#b0 358 1	0.69 019 6	0.20 784 3	0.50 588 2	0.89 701 9	0.69 886 4	0.69 019 6	167 325 6	0.167984	322	320
1_2 6	#86 2f5 b	0.52 549	0.18 431 4	0.35 686 3	0.91 570 9	0.64 925 4	0.52 549	747 363	0.07503	329	325
1_2 6	#43 081 b	0.26 274 5	0.03 137 3	0.10 588 2	0.94 632 8	0.88 059 7	0.26 274 5	860 076	0.086346	340	340
1_2 6	#87 044 e	0.52 941 2	0.01 568 6	0.30 588 2	0.90 585 2	0.97 037 2	0.52 941 2	203 741 2	0.204542	326	325
1_2 6	#bf 82a a	0.74 902	0.50 980 4	0.66 666 7	0.89 071	0.31 937 2	0.74 902	139 590	0.014014	320	320
1_3 1	#75 2b4 8	0.45 882 4	0.16 862 7	0.28 235 3	0.93 468 5	0.63 247 9	0.45 882 4	134 160	0.002131	336	335
1_3 1	#b7 2c8 4	0.71 764 7	0.17 254 9	0.51 764 7	0.89 448 4	0.75 956 3	0.71 764 7	294 426	0.004677	322	320
1_3 1	#84 034 6	0.51 764 7	0.01 176 5	0.27 451	0.91 343 7	0.97 727 3	0.51 764 7	336 713	0.005349	328	325
1_3 1	#d2 d2d 2	0.82 352 9	0.82 352 9	0.82 352 9	0	0	0.82 352 9	611 263 53	0.970988	0	0
1_3 1	#aa 066 d	0.66 666 7	0.02 352 9	0.42 745 1	0.89 532 5	0.96 470 6	0.66 666 7	263 930	0.004193	322	320
1_3 1	#98 1e6 2	0.59 607 8	0.11 764 7	0.38 431 4	0.90 710 4	0.80 263 2	0.59 607 8	174 272	0.002768	326	325
1_3 1	#c2 3f9 3	0.76 078 4	0.24 705 9	0.57 647 1	0.89 313	0.67 525 8	0.76 078 4	137 070	0.002177	321	320
1_3 1	#57 072 3	0.34 117 6	0.02 745 1	0.13 725 5	0.94 166 7	0.91 954	0.34 117 6	269 424	0.00428	339	335
1_3 1	#9d 407 0	0.61 568 6	0.25 098	0.43 921 6	0.91 397 8	0.59 235 7	0.61 568 6	126 543	0.00201	329	325

1_3 1	#c1 579 c	0.75 686 3	0.34 117 6	0.61 176 5	0.89 150 9	0.54 922 3	0.75 686 3	898 65	0.001427	320	320
1_3 2	#ae 64a c	0.68 235 3	0.39 215 7	0.67 451	0.83 783 8	0.42 528 7	0.68 235 3	209 064	0.025921	301	300
1_3 2	#a1 449 b	0.63 137 3	0.26 666 7	0.60 784 3	0.84 408 6	0.57 764 3	0.63 137 3	608 730	0.075475	303	300
1_3 2	#86 457 d	0.52 549	0.27 058 8	0.49 019 6	0.85 641	0.48 507 5	0.52 549	389 391	0.048279	308	305
1_3 2	#61 074 5	0.38 039 2	0.02 745 1	0.27 058 8	0.88 518 5	0.92 783 5	0.38 039 2	177 939 6	0.220622	318	315
1_3 2	#97 2a8 a	0.59 215 7	0.16 470 6	0.54 117 6	0.85 321 1	0.72 185 4	0.59 215 7	736 119	0.091269	307	305
1_3 2	#3d 052 2	0.23 921 6	0.01 960 8	0.13 333 3	0.91 369	0.91 803 3	0.23 921 6	116 235 6	0.144117	328	325
1_3 2	#82 277 4	0.50 980 4	0.15 294 1	0.45 490 2	0.85 897 4	0.7 980 4	0.50 980 4	111 471 0	0.13821	309	305
1_3 2	#7c 096 5	0.48 627 5	0.03 529 4	0.39 607 8	0.86 666 7	0.92 741 9	0.48 627 5	110 788 2	0.137363	312	310
1_3 2	#6d 235 c	0.42 745 1	0.13 725 5	0.36 078 4	0.87 162 2	0.67 889 9	0.42 745 1	957 707	0.118743	313	310
1_3 3	#b3 8cb 4	0.70 196 1	0.54 902	0.70 588 2	0.82 916 7	0.22 222 2	0.70 588 2	276 03	0.015274	298	295
1_3 3	#7a 2d6 4	0.47 843 1	0.17 647 1	0.39 215 7	0.88 095 2	0.63 114 8	0.47 843 1	232 185	0.128475	317	315
1_3 3	#88 3d7 d	0.53 333 3	0.23 921 6	0.49 019 6	0.85 777 8	0.55 147 1	0.53 333 3	307 671	0.170244	308	305
1_3 3	#93 4c8 f	0.57 647 1	0.29 803 9	0.56 078 4	0.84 272 3	0.48 299 3	0.57 647 1	340 992	0.188682	303	300

1_3 3	#a7 6aa b	0.65 490 2	0.41 568 6	0.67 058 8	0.82 307 7	0.38 011 7	0.67 058 8	147 738	0.081748	296	295
1_3 3	#6b 1b4 b	0.41 960 8	0.10 588 2	0.29 411 8	0.9	0.74 766 4	0.41 960 8	180 436	0.099841	324	320
1_3 3	#9f 56a 0	0.62 352 9	0.33 725 5	0.62 745 1	0.83 108 1	0.46 25 1	0.62 745 1	249 327	0.13796	299	295
1_3 3	#53 0f3 1	0.32 549 1	0.05 882 4	0.19 215 7	0.91 666 7	0.81 927 7	0.32 549	187 119	0.103539	330	330
1_3 3	#35 0a1 c	0.20 784 3	0.03 921 6	0.10 980 4	0.93 023 3	0.81 132 1	0.20 784 3	134 165	0.074238	334	330
1_3 6	#b6 77b 2	0.71 372 5	0.46 666 7	0.69 803 9	0.84 391 5	0.34 615 4	0.71 372 5	118 671	0.001915	303	300
1_3 6	#dc afd 6	0.86 274 5	0.68 627 5	0.83 921 6	0.85 555 6	0.20 454 5	0.86 274 5	33	5.326446098 641327e_07	308	305
1_3 6	#c3 91c 3	0.76 470 6	0.56 862 7	0.76 470 6	0.83 333 3	0.25 641 6	0.76 470 6	127 05	0.000205	300	300
1_3 6	#fdf afb 7	0.99 215 7	0.98 039 2	0.98 431 4	0.94 444 4	0.01 185 8	0.99 215 7	100 680	0.001625	340	340
1_3 6	#d6 d6d 6	0.83 921 6	0.83 921 6	0.83 921 6	0	0	0.83 921 6	599 522 52	0.967674	0	0
1_3 6	#a5 539 b	0.64 705 9	0.32 549	0.60 784 3	0.85 365 9	0.49 697	0.64 705 9	361 680	0.005838	307	305
1_3 6	#62 0f3 c	0.38 431 4	0.05 882 4	0.23 529 4	0.90 963 9	0.84 693 9	0.38 431 4	795 264	0.012836	327	325
1_3 6	#f8f efc 9	0.97 254 9	0.99 607 8	0.98 823 5	0.44 444 4	0.02 362 2	0.99 607 8	635 67	0.001026	160	160
1_3 6	#8b 2a7 0	0.54 509 8	0.16 470 6	0.43 921 6	0.87 972 5	0.69 784 2	0.54 509 8	550 154	0.00888	316	315

1_3 7	#ac 7ab 2	0.67 451	0.47 843 1	0.69 803 9	0.81 547 6	0.31 460 7	0.69 803 9	536 43	0.012602	293	290
1_3 7	#5b 0e3 e	0.35 686 3	0.05 490 2	0.24 313 7	0.89 610 4	0.84 615 4	0.35 686 3	783 973	0.184172	322	320
1_3 7	#a4 58a 7	0.64 313 7	0.34 509 8	0.65 490 2	0.82 700 4	0.47 305 4	0.65 490 2	245 655	0.05771	297	295
1_3 7	#fcf cfc	0.98 823 5	0.98 823 5	0.98 823 5	0 0	0 0	0.98 823 5	305 790	0.071837	0	0
1_3 7	#7a 356 e	0.47 843 1	0.20 784 3	0.43 137 3	0.86 231 9	0.56 557 4	0.47 843 1	474 783	0.111537	310	310
1_3 7	#8c 288 0	0.54 902 0	0.15 686 3	0.50 196 1	0.85 333 3	0.71 428 6	0.54 902 0	551 991	0.129674	307	305
1_3 7	#97 419 3	0.59 215 7	0.25 490 2	0.57 647 1	0.84 108 5	0.56 953 6	0.59 215 7	535 989	0.125915	302	300
1_3 7	#37 081 f	0.21 568 6	0.03 137 3	0.12 156 9	0.91 844 9	0.85 454 5	0.21 568 6	550 557	0.129338	330	330
1_3 7	#75 145 e	0.45 882 4	0.07 843 1	0.36 862 7	0.87 285 2	0.82 906 0	0.45 882 4	754 363	0.177216	314	310
1_3 8	#76 032 a	0.46 274 5	0.01 176 5	0.16 470 6	0.94 347 8	0.97 457 6	0.46 274 5	105 08	0.020813	339	335
1_3 8	#94 529 0	0.58 039 2	0.32 156 9	0.56 470 6	0.84 343 4	0.44 594 6	0.58 039 2	604 62	0.119757	303	300
1_3 8	#59 0e3 9	0.34 902 9	0.05 490 2	0.22 352 9	0.90 444 4	0.84 269 7	0.34 902 9	720 50	0.142709	325	325
1_3 8	#6e 1f5 3	0.43 137 3	0.12 156 9	0.32 549 5	0.89 029 5	0.71 818 2	0.43 137 3	647 07	0.128165	320	320
1_3 8	#7e 1a6 d	0.49 411 8	0.10 196 1	0.42 745 1	0.86 166 7	0.79 365 1	0.49 411 8	687 01	0.136076	310	310

1_3 8	#81 3b6 c	0.50 588 2	0.23 137 3	0.42 352 9	0.88 333 3	0.54 263 6	0.50 588 2	593 46	0.117547	318	315
1_3 8	#3a 0c2 1	0.22 745 1	0.04 705 9	0.12 941 2	0.92 391 3	0.79 310 3	0.22 745 1	516 27	0.102258	332	330
1_3 8	#8e 328 8	0.55 686 3	0.19 607 8	0.53 333 3	0.84 420 3	0.64 788 7	0.55 686 3	104 616	0.207213	303	300
1_3 8	#a8 7ba 4	0.65 882 4	0.48 235 3	0.64 313 7	0.84 814 8	0.26 785 7	0.65 882 4	128 55	0.025462	305	305
1_3 9	#4f 0c2 d	0.30 980 4	0.04 705 9	0.17 647 1	0.91 791	0.84 810 1	0.30 980 4	542 948	0.010105	330	330
1_3 9	#8f 2e7 d	0.56 078 4	0.18 039 2	0.49 019 6	0.86 426 1	0.67 832 2	0.56 078 4	507 844	0.009452	311	310
1_3 9	#76 0c5 7	0.46 274 5	0.04 705 9	0.34 117 6	0.88 207 5	0.89 830 5	0.46 274 5	591 606	0.011011	317	315
1_3 9	#fef cfd	0.99 607 8	0.98 823 5	0.99 215 7	0.91 666 7	0.00 787 4	0.99 607 8	169 119	0.003148	330	330
1_3 9	#faf 8f7	0.98 039 2	0.97 254 9	0.96 862 7	0.05 555 6	0.01 2	0.98 039 2	160 38	0.000298	19	15
1_3 9	#b2 6ea b	0.69 803 9	0.43 137 3	0.67 058 8	0.85 049	0.38 202 2	0.69 803 9	860 10	0.001601	306	305
1_3 9	#9f 4b9 3	0.62 352 9	0.29 411 8	0.57 647 1	0.85 714 3	0.52 830 2	0.62 352 9	405 309	0.007543	308	305
1_3 9	#79 305 e	0.47 451	0.18 823 5	0.36 862 7	0.89 497 7	0.60 330 6	0.47 451	314 148	0.005847	322	320
1_3 9	#f3f dfa	0.95 294 1	0.99 215 7	0.98 039 2	0.45	0.03 952 6	0.99 215 7	797 7	0.000148	161	160
1_3 9	#fcf cfc	0.98 823 5	0.98 823 5	0.98 823 5	0	0	0.98 823 5	510 899 31	0.950848	0	0

1_0 4	#9c 055 2	0.61 176 5	0.01 960 8	0.32 156 9	0.91 501 1	0.96 794 9	0.61 176 5	335 178	0.172127	329	325
1_0 4	#d5 3f9 8	0.83 529 4	0.24 705 9	0.59 607 8	0.90 111 1	0.70 422 5	0.83 529 4	195 747	0.100523	324	320
1_0 4	#bb 127 6	0.73 333 3	0.07 058 8	0.46 274 5	0.90 138 1	0.90 374 3	0.73 333 3	339 476	0.174334	324	320
1_0 4	#de 64a 9	0.87 058 8	0.39 215 7	0.66 274 5	0.90 573 8	0.54 955 8	0.87 058 8	104 211	0.053516	326	325
1_0 4	#e8 8cb c	0.90 980 4	0.54 902 9	0.73 725 5	0.91 304 3	0.39 655 2	0.90 980 4	477 27	0.02451	328	325
1_0 4	#94 2d6 3	0.58 039 2	0.17 647 1	0.38 823 5	0.91 262 1	0.69 594 6	0.58 039 2	201 459	0.103457	328	325
1_0 4	#64 082 6	0.39 215 7	0.03 137 3	0.14 902	0.94 565 2	0.92	0.39 215 7	194 159	0.099708	340	340
1_0 4	#bf 568 e	0.74 902	0.33 725 5	0.55 686 3	0.91 111 1	0.54 973 8	0.74 902	113 040	0.05805	328	325
1_0 4	#bc 358 3	0.73 725 5	0.20 784 3	0.51 372 5	0.90 370 4	0.71 808 5	0.73 725 5	416 280	0.213775	325	325
1_4 1	#faf af8	0.98 039 2	0.98 039 2	0.97 254 9	0.16 666 7	0.00 8	0.98 039 2	102 300	0.011119	59	55
1_4 1	#7c 186 7	0.48 627 5	0.09 411 8	0.40 392 2	0.86 833 3	0.80 645 2	0.48 627 5	207 821 1	0.225889	312	310
1_4 1	#fef cfe	0.99 607 8	0.98 823 5	0.99 607 8	0.83 333 3	0.00 787 4	0.99 607 8	465 345	0.05058	300	300
1_4 1	#56 063 5	0.33 725 5	0.02 352 9	0.20 784 3	0.90 208 3	0.93 023 3	0.33 725 5	184 356 6	0.200385	324	320
1_4 1	#f8f efd	0.97 254 9	0.99 607 8	0.99 215 7	0.47 222 2	0.02 362 2	0.99 607 8	969 00	0.010532	170	170

1_4 1	#6c 075 2	0.42 352 9	0.02 745 1	0.32 156 9	0.87 623 8	0.93 518 5	0.42 352 9	220 091 1	0.239226	315	315
1_4 1	#8a 307 b	0.54 117 6	0.18 823 5	0.48 235 3	0.86 111 1	0.65 217 4	0.54 117 6	119 382 9	0.129762	310	310
1_4 1	#9e 529 0	0.61 960 8	0.32 156 9	0.56 470 6	0.86 403 5	0.48 101 3	0.61 960 8	215 385	0.023411	311	310
1_4 1	#38 061 c	0.21 960 8	0.02 352 9	0.10 980 4	0.92 666 7	0.89 285 7	0.21 960 8	100 367 7	0.109094	333	330
1_4 4	#af 79a 4	0.68 627 5	0.47 451 7	0.64 313 7	0.86 728 4	0.30 857 1	0.68 627 5	890 16	0.015544	312	310
1_4 4	#42 072 0	0.25 882 4	0.02 745 1	0.12 549 9	0.92 937 9	0.89 393 9	0.25 882 4	115 288 1	0.201317	334	330
1_4 4	#9c 1e8 6	0.61 176 5	0.11 764 7	0.52 549 4	0.86 243 4	0.80 769 2	0.61 176 5	554 879	0.096893	310	310
1_4 4	#66 043 e	0.4 568 6	0.01 313 7	0.24 136 1	0.90 078 4	0.96 078 4	0.4 278 1	116 278 1	0.203046	324	320
1_4 4	#5d 233 d	0.36 470 6	0.13 725 5	0.23 921 6	0.92 528 7	0.62 365 6	0.36 470 6	292 710	0.051113	333	330
1_4 4	#7c 275 7	0.48 627 5	0.15 294 1	0.34 117 6	0.90 588 2	0.68 548 4	0.48 627 5	451 761	0.078887	326	325
1_4 4	#8c 237 2	0.54 902 5	0.13 725 9	0.44 705 3	0.87 460 3	0.75 902 613	0.54 902 613	638 613	0.111515	314	310
1_4 4	#81 046 1	0.50 588 2	0.01 568 6	0.38 039 2	0.87 6 899	0.96 899 2	0.50 588 2	911 769	0.159214	315	315
1_4 4	#a4 469 3	0.64 313 7	0.27 451 1	0.57 647 5	0.86 347 1	0.57 317 1	0.64 313 7	472 290	0.082472	310	310
1_4 6	#78 215 6	0.47 058 8	0.12 941 2	0.33 725 5	0.89 846 7	0.72 5 058	0.47 058 8	135 270	0.002434	323	320

1_4 6	#fcf cfc	0.98 823 5	0.98 823 5	0.98 823 5	0 0	0 0	0.98 823 5	314 37	0.000566	0	0
1_4 6	#96 317 d	0.58 823 5	0.19 215 7	0.49 019 6	0.87 458 7	0.67 333 3	0.58 823 5	960 36	0.001728	314	310
1_4 6	#5f 103 7	0.37 254 9	0.06 274 5	0.21 568 6	0.91 772 2	0.83 157 9	0.37 254 9	116 770	0.002101	330	330
1_4 6	#af 48a 0	0.68 627 5	0.28 235 3	0.62 745 1	0.85 760 5	0.58 857 1	0.68 627 5	868 89	0.001564	308	305
1_4 6	#f7f af8	0.96 862 7	0.98 039 2	0.97 254 9	0.38 888 9	0.01 2	0.98 039 2	522 9	9.409304926 241684e_05	140	140
1_4 6	#ea eae a	0.91 764 7	0.91 764 7	0.91 764 7	0 0	0 0	0.91 764 7	550 185 09	0.990029	0	0
1_4 6	#8f 678 5	0.56 078 4	0.40 392 2	0.52 156 9	0.87 5	0.27 972	0.56 078 4	678 0	0.000122	315	315
1_4 6	#3b 081 b	0.23 137 3	0.03 137 3	0.10 588 2	0.93 790 8	0.86 440 7	0.23 137 3	757 29	0.001363	337	335
1_4 7	#fbf bfb	0.98 431 4	0.98 431 4	0.98 431 4	0 0	0 0	0.98 431 4	369 45	0.000658	0	0
1_4 7	#be 6ab 7	0.74 509 8	0.41 568 6	0.71 764 7	0.84 722 2	0.44 210 5	0.74 509 8	812 04	0.001447	305	305
1_4 7	#f7f af6	0.96 862 7	0.98 039 2	0.96 470 6	0.29 166 7	0.01 6	0.98 039 2	387 0	6.894698516 658171e_05	105	105
1_4 7	#5b 0a3 7	0.35 686 3	0.03 921 6	0.21 568 6	0.90 740 7	0.89 011	0.35 686 3	316 674	0.005642	326	325
1_4 7	#f1f 3f2	0.94 509 8	0.95 294 1	0.94 902	0.41 666 7	0.00 823	0.95 294 1	45	8.017091298 439733e_07	150	150
1_4 7	#a4 419 8	0.64 313 7	0.25 490 2	0.59 607 8	0.85 353 5	0.60 365 9	0.64 313 7	270 738	0.004823	307	305

1_4 7	#cb 96c 9	0.79 607 8	0.58 823 5	0.78 823 5	0.83 962 3	0.26 108 4	0.79 607 8	114 15	0.000203	302	300
1_4 7	#8a 147 0	0.54 117 6	0.07 843 1	0.43 921 6	0.87 005 6	0.85 507 2	0.54 117 6	415 139	0.007396	313	310
1_4 7	#ea eae a	0.91 764 7	0.91 764 7	0.91 764 7	0 0	0 0	0.91 764 7	549 940 53	0.979761	0	0
1_4 8	#4f 063 0	0.30 980 4	0.02 352 9	0.18 823 5	0.90 411	0.92 405 1	0.30 980 4	188 504 3	0.030461	325	325
1_4 8	#78 045 e	0.47 058 8	0.01 568 6	0.36 862 7	0.87 069	0.96 666 7	0.47 058 8	180 694 8	0.029199	313	310
1_4 8	#77 2b5 d	0.46 666 7	0.16 862 7	0.36 470 6	0.89 035 1	0.63 865 5	0.46 666 7	719 853	0.011632	320	320
1_4 8	#97 228 6	0.59 215 7	0.13 333 3	0.52 549	0.85 755	0.77 483 4	0.59 215 7	123 184 1	0.019906	308	305
1_4 8	#ecf 9ee	0.92 549	0.97 647 1	0.93 333 3	0.35 897 4	0.05 220 9	0.97 647 1	36	5.817338104 369316e_07	129	125
1_4 8	#b0 7fae	0.69 019 6	0.49 803 9	0.68 235 3	0.84 013 6	0.27 840 9	0.69 019 6	805 71	0.001302	302	300
1_4 8	#e8 e8e 8	0.90 980 4	0.90 980 4	0.90 980 4	0 0	0 0	0.90 980 4	554 374 11	0.895828	0	0
1_4 8	#fbf bfb	0.98 431 4	0.98 431 4	0.98 431 4	0 0	0 0	0.98 431 4	216 006	0.00349	0	0
1_4 8	#c6 9bc 6	0.77 647 1	0.60 784 3	0.77 647 1	0.83 333 3	0.21 717 2	0.77 647 1	565 5	9.138068605 613468e_05	300	300
1_4 8	#a9 4ba 0	0.66 274 5	0.29 411 8	0.62 745 1	0.84 929 1	0.55 621 3	0.66 274 5	500 610	0.008089	305	305
1_0 5	#77 234 d	0.46 666 7	0.13 725 5	0.30 196 1	0.91 666 7	0.70 588 2	0.46 666 7	511 998	0.008224	330	330

1_0 5	#6a 063 c	0.41 568 6	0.02 352 9	0.23 529 4	0.91	0.94 339 6	0.41 568 6	795 334	0.012776	327	325
1_0 5	#86 456 7	0.52 549	0.27 058 8	0.40 392 2	0.91 282 1	0.48 507 5	0.52 549	241 920	0.003886	328	325
1_0 5	#ae 4b9 d	0.68 235 3	0.29 411 8	0.61 568 6	0.86 195 3	0.56 896 6	0.68 235 3	750 474	0.012055	310	310
1_0 5	#bf 6fb 0	0.74 902	0.43 529 4	0.69 019 6	0.86 458 3	0.41 884 8	0.74 902	279 186	0.004485	311	310
1_0 5	#41 0c2 1	0.25 490 2	0.04 705 9	0.12 941 2	0.93 396 2	0.81 538 5	0.25 490 2	528 073	0.008483	336	335
1_0 5	#e2 e2e 2	0.88 627 5	0.88 627 5	0.88 627 5	0	0	0.88 627 5	568 540 83	0.913259	0	0
1_0 5	#96 287 9	0.58 823 5	0.15 686 3	0.47 451	0.87 727 3	0.73 333 3	0.58 823 5	738 021	0.011855	315	315
1_0 5	#a7 2f9 2	0.65 490 2	0.18 431 4	0.57 254 9	0.86 25	0.71 856 3	0.65 490 2	785 293	0.012614	310	310
1_0 5	#89 096 8	0.53 725 5	0.03 529 4	0.40 784 3	0.87 630 2	0.93 430 7	0.53 725 5	769 693	0.012364	315	315
1_5 1	#97 0a8 4	0.59 215 7	0.03 921 6	0.51 764 7	0.85 579 2	0.93 377 5	0.59 215 7	126 319 6	0.020176	308	305
1_5 1	#7e 036 5	0.49 411 8	0.01 176 5	0.39 607 8	0.86 720 9	0.97 619	0.49 411 8	154 172 0	0.024624	312	310
1_5 1	#62 074 2	0.38 431 4	0.02 745 1	0.25 882 4	0.89 194 1	0.92 857 1	0.38 431 4	165 522 9	0.026437	321	320
1_5 1	#ea eae a	0.91 764 7	0.91 764 7	0.91 764 7	0	0	0.91 764 7	548 571 93	0.876176	0	0
1_5 1	#a3 2a9 5	0.63 921 6	0.16 470 6	0.58 431 4	0.85 261 7	0.74 233 1	0.63 921 6	964 182	0.0154	306	305

1_5 1	#bc 7fb a	0.73 725 5	0.49 803 9	0.72 941 2	0.83 879 8	0.32 446 8	0.73 725 5	786 51	0.001256	301	300
1_5 1	#8c 5e8 6	0.54 902	0.36 862 7	0.52 549	0.85 507 2	0.32 857 1	0.54 902	151 620	0.002422	307	305
1_5 1	#80 276 b	0.50 196 1	0.15 294 1	0.41 960 8	0.87 265 9	0.69 531 3	0.50 196 1	793 380	0.012672	314	310
1_5 1	#3b 072 1	0.23 137 3	0.02 745 1	0.12 941 2	0.91 666 7	0.88 135 6	0.23 137 3	955 518	0.015261	330	330
1_5 1	#b2 45a a	0.69 803 9	0.27 058 8	0.66 666 7	0.84 556 6	0.61 236	0.69 803 9	349 101	0.005576	304	300
1_5 1	#4d 043 3	0.30 196 1	0.01 568 6	0.2	0.89 269 4	0.94 805 2	0.30 196 1	547 296	0.008414	321	320
1_5 1	#69 025 a	0.41 176 5	0.00 784 3	0.35 294 1	0.85 760 5	0.98 095 2	0.41 176 5	313 322	0.004817	308	305
1_5 1	#cd cdc d	0.80 392 2	0.80 392 2	0.80 392 2	0	0	0.80 392 2	628 448 70	0.966114	0	0
1_5 1	#78 156 d	0.47 058 8	0.08 235 3	0.42 745 1	0.85 185 2	0.82 5	0.47 058 8	158 283	0.002433	306	305
1_5 1	#9e 5da 6	0.61 960 8	0.36 470 6	0.65 098	0.81 506 8	0.43 975 9	0.65 098	557 91	0.000858	293	290
1_5 1	#73 385 d	0.45 098	0.21 960 8	0.36 470 6	0.89 548	0.51 304 3	0.45 098	781 29	0.001201	322	320
1_5 1	#59 1e4 0	0.34 902	0.11 764 7	0.25 098	0.90 395 5	0.66 292 1	0.34 902	148 296	0.00228	325	325
1_5 1	#8b 398 7	0.54 509 8	0.22 352 9	0.52 941 2	0.84 146 3	0.58 992 8	0.54 509 8	851 01	0.001308	302	300
1_5 1	#2c 041 5	0.17 254 9	0.01 568 6	0.08 235 3	0.92 916 7	0.90 909 1	0.17 254 9	677 785	0.01042	334	330

1_5 1	#8c 128 5	0.54 902	0.07 058 8	0.52 156 9	0.84 289 6	0.87 142 9	0.54 902	140 257	0.002156	303	300
1_5 3	#a6 439 f	0.65 098	0.26 274 5	0.62 352 9	0.84 511 8	0.59 638 6	0.65 098	136 125 0	0.162314	304	300
1_5 3	#7c 0b6 2	0.48 627 5	0.04 313 7	0.38 431 4	0.87 168 1	0.91 129	0.48 627 5	891 393	0.106288	313	310
1_5 3	#64 0d4 3	0.39 215 7	0.05 098	0.26 274 5	0.89 655 2	0.87	0.39 215 7	120 037 4	0.143131	322	320
1_5 3	#81 276 c	0.50 588 2	0.15 294 1	0.42 352 9	0.87 222 2	0.69 767 4	0.50 588 2	973 308	0.116056	314	310
1_5 3	#69 345 a	0.41 176 5	0.20 392 2	0.35 294 1	0.88 050 3	0.50 476 2	0.41 176 5	482 526	0.057536	316	315
1_5 3	#b0 64a f	0.69 019 6	0.39 215 7	0.68 627 5	0.83 552 6	0.43 181 8	0.69 019 6	820 434	0.097827	300	300
1_5 3	#40 082 4	0.25 098	0.03 137 3	0.14 117 6	0.91 666 7	0.87 5	0.25 098	724 640	0.086405	330	330
1_5 3	#90 488 3	0.56 470 6	0.28 235 3	0.51 372 5	0.86 342 6	0.5	0.56 470 6	668 979	0.079768	310	310
1_5 3	#95 268 5	0.58 431 4	0.14 902	0.52 156 9	0.85 735 7	0.74 496 6	0.58 431 4	126 364 1	0.150675	308	305
1_5 4	#ac 4ba 4	0.67 451	0.29 411 8	0.64 313 7	0.84 707 9	0.56 395 3	0.67 451	116 460 0	0.201409	304	300
1_5 4	#43 0b2 5	0.26 274 5	0.04 313 7	0.14 509 8	0.92 261 9	0.83 582 1	0.26 274 5	384 358	0.066472	332	330
1_5 4	#5b 1b3 f	0.35 686 3	0.10 588 2	0.24 705 9	0.90 625	0.70 329 7	0.35 686 3	466 440	0.080667	326	325
1_5 4	#a1 308 f	0.63 137 3	0.18 823 5	0.56 078 4	0.85 988 2	0.70 186 3	0.63 137 3	912 854	0.157871	309	305

1_5 4	#72 0b4 9	0.44 705 9	0.04 313 7	0.28 627 5	0.89 967 6	0.90 350 9	0.44 705 9	555 110	0.096002	323	320
1_5 4	#8b 196 a	0.54 509 8	0.09 803 9	0.41 568 6	0.88 157 9	0.82 014 4	0.54 509 8	736 937	0.127448	317	315
1_5 4	#6f 305 9	0.43 529 4	0.18 823 5	0.34 902	0.89 153 4	0.56 756 8	0.43 529 4	424 512	0.073416	320	320
1_5 4	#8c 407 a	0.54 902	0.25 098	0.47 843 1	0.87 280 7	0.54 285 7	0.54 902	590 895	0.102191	314	310
1_5 4	#b6 67b 6	0.71 372 5	0.40 392 2	0.71 372 5	0.83 333 3	0.43 406 6	0.71 372 5	546 564	0.094524	300	300
1_5 7	#b8 69b 4	0.72 156 9	0.41 176 5	0.70 588 2	0.84 177 2	0.42 934 8	0.72 156 9	525 075	0.141528	303	300
1_5 7	#3b 0f2 0	0.23 137 3	0.05 882 4	0.12 549	0.93 560 6	0.74 576 3	0.23 137 3	138 461	0.037321	336	335
1_5 7	#7d 065 7	0.49 019 6	0.02 352 9	0.34 117 6	0.88 655 5	0.95 2	0.49 019 6	413 108	0.111349	319	315
1_5 7	#ab 409 f	0.67 058 8	0.25 098	0.62 352 9	0.85 202 5	0.62 573 1	0.67 058 8	815 667	0.219854	306	305
1_5 7	#94 428 1	0.58 039 2	0.25 882 4	0.50 588 2	0.87 195 1	0.55 405 4	0.58 039 2	335 505	0.090432	313	310
1_5 7	#9c 188 4	0.61 176 5	0.09 411 8	0.51 764 7	0.86 363 6	0.84 615 4	0.61 176 5	529 218	0.142645	310	310
1_5 7	#61 073 4	0.38 039 2	0.02 745 1	0.20 392 2	0.91 666 7	0.92 783 5	0.38 039 2	330 297	0.089028	330	330
1_5 7	#88 256 7	0.53 333 3	0.14 509 8	0.40 392 2	0.88 888 9	0.72 794 1	0.53 333 3	384 984	0.103768	320	320
1_5 7	#67 2a4 9	0.40 392 2	0.16 470 6	0.28 627 5	0.91 530 1	0.59 223 3	0.40 392 2	237 723	0.064076	329	325

1_5 9	#98 2b8 d	0.59 607 8	0.16 862 7	0.55 294 1	0.85 015 3	0.71 710 5	0.59 607 8	342 088	0.211348	306	305
1_5 9	#82 2b6 5	0.50 980 4	0.16 862 7	0.39 607 8	0.88 888 9	0.66 923 1	0.50 980 4	142 215	0.087863	320	320
1_5 9	#a5 44a 5	0.64 705 9	0.26 666 7	0.64 705 9	0.83 333 3	0.58 787 9	0.64 705 9	157 344	0.09721	300	300
1_5 9	#88 0b7 3	0.53 333 3	0.04 313 7	0.45 098	0.86 133 3	0.91 911 8	0.53 333 3	265 207	0.163849	310	310
1_5 9	#a4 508 f	0.64 313 7	0.31 372 5	0.56 078 4	0.87 5	0.51 219 5	0.64 313 7	430 35	0.026588	315	315
1_5 9	#68 0d4 a	0.40 784 3	0.05 098	0.29 019 6	0.88 827 8	0.87 5	0.40 784 3	315 835	0.195128	319	315
1_5 9	#b3 76b 7	0.70 196 1	0.46 274 5	0.71 764 7	0.82 307 7	0.35 519 1	0.71 764 7	409 11	0.025276	296	295
1_5 9	#fbf bfc	0.98 431 4	0.98 431 4	0.98 823 5	0.66 666 7	0.00 396 8	0.98 823 5	742 23	0.045856	240	240
1_5 9	#3b 0a2 2	0.23 137 3	0.03 921 6	0.13 333 3	0.91 836 7	0.83 050 8	0.23 137 3	237 744	0.146882	330	330
1_6 0	#77 073 1	0.46 666 7	0.02 745 1	0.19 215 7	0.93 75	0.94 117 6	0.46 666 7	526 673	0.008418	337	335
1_6 0	#b3 076 c	0.70 196 1	0.02 745 1	0.42 352 9	0.90 213 2	0.96 089 4	0.70 196 1	396 795	0.006342	324	320
1_6 0	#d8 d8d 8	0.84 705 9	0.84 705 9	0.84 705 9	0	0	0.84 705 9	595 743 81	0.95223	0	0
1_6 0	#99 035 0	0.6 176 5	0.01 176 5	0.31 372 5	0.91 444 4	0.98 039 2	0.6	498 595	0.007969	329	325
1_6 0	#c7 118 1	0.78 039 2	0.06 666 7	0.50 588 2	0.89 743 6	0.91 457 3	0.78 039 2	186 206	0.002976	323	320

1_6 0	#9e 2d6 9	0.61 960 8	0.17 647 1	0.41 176 5	0.91 150 4	0.71 519 8	0.61 960 8	313 509	0.005011	328	325
1_6 0	#c3 348 9	0.76 470 6	0.20 392 2	0.53 725 5	0.90 093 2	0.73 333 3	0.76 470 6	332 073	0.005308	324	320
1_6 0	#d7 60a 9	0.84 313 7	0.37 647 1	0.66 274 5	0.89 775 9	0.55 348 8	0.84 313 7	135 909	0.002172	323	320
1_6 0	#45 081 8	0.27 058 8	0.03 137 3	0.09 411 8	0.95 628 4	0.88 405 8	0.27 058 8	489 187	0.007819	344	340
1_6 0	#b0 5b8 5	0.69 019 6	0.35 686 3	0.52 156 9	0.91 764 7	0.48 295 5	0.69 019 6	109 719	0.001754	330	330
1_6 1	#ab 176 3	0.67 058 8	0.09 019 6	0.38 823 5	0.91 441 4	0.86 549 7	0.67 058 8	253 234	0.004565	329	325
1_6 1	#5a 112 7	0.35 294 1	0.06 666 7	0.15 294 1	0.94 977 2	0.81 111 1	0.35 294 1	153 345	0.002765	341	340
1_6 1	#ed ede d	0.92 941 2	0.92 941 2	0.92 941 2	0 0	0 0	0.92 941 2	543 133 59	0.97917	0	0
1_6 1	#c0 398 5	0.75 294 1	0.22 352 9	0.52 156 9	0.90 617 3	0.70 312 5	0.75 294 1	272 138	0.004906	326	325
1_6 1	#df 88b 9	0.87 451 9	0.53 333 3	0.72 549 5	0.90 613 5	0.39 013 5	0.87 451 70	407 70	0.000735	326	325
1_6 1	#e6 bed 8	0.90 196 1	0.74 509 8	0.84 705 9	0.89 166 7	0.17 391 3	0.90 196 1	6	1.081689477 8151257e_0 7	321	320
1_6 1	#fef bfc 8	0.99 607 8	0.98 431 4	0.98 823 5	0.94 444 4	0.01 181 1	0.99 607 8	100 074	0.001804	339	335
1_6 1	#d7 5aa 1	0.84 313 7	0.35 294 1	0.63 137 3	0.90 533 3	0.58 139 5	0.84 313 7	129 375	0.002332	325	325
1_6 1	#f1f 7f4 8	0.94 509 8	0.96 862 7	0.95 686 3	0.41 666 7	0.02 429 1	0.96 862 7	345	6.219714497 436973e_06	150	150

1_6 1	#81 1c4 1	0.50 588 2	0.10 980 4	0.25 490 2	0.93 894 4	0.78 294 6	0.50 588 2	206 138	0.003716	338	335
1_6 2	#8e 355 c	0.55 686 3	0.20 784 3	0.36 078 4	0.92 696 6	0.62 676 1	0.55 686 3	326 730	0.005008	333	330
1_6 2	#56 0e2 5	0.33 725 5	0.05 490 2	0.14 509 8	0.94 675 9	0.83 720 9	0.33 725 5	487 849	0.007478	340	340
1_6 2	#da 90c 0	0.85 490 2	0.56 470 6	0.75 294 1	0.89 189 2	0.33 945 2	0.85 490 2	204 069	0.003128	321	320
1_6 2	#96 074 3	0.58 823 5	0.02 745 1	0.26 274 5	0.93 007 3	0.95 333 3	0.58 823 5	522 946	0.008016	334	330
1_6 2	#c9 68a 6	0.78 823 5	0.40 784 3	0.65 098 1	0.89 347 7	0.48 258 5	0.78 823 5	566 415	0.008682	321	320
1_6 2	#e3 6fb 8	0.89 019 6	0.43 529 4	0.72 156 9	0.89 511 5	0.51 101 3	0.89 019 6	353 214	0.005414	322	320
1_6 2	#9e 5d7 b	0.61 960 8	0.36 470 6	0.48 235 3	0.92 307 7	0.41 139 2	0.61 960 8	461 76	0.027242	332	330
1_6 2	#a7 0e5 0	0.65 490 2	0.05 490 2	0.31 372 5	0.92 810 5	0.91 616 8	0.65 490 2	331 316	0.195463	334	330
1_6 2	#c6 387 b	0.77 647 1	0.21 960 8	0.48 235 3	0.92 136 2	0.71 717 2	0.77 647 1	116 235	0.068574	331	330
1_6 2	#75 062 b	0.45 882 4	0.02 352 9	0.16 862 7	0.94 444 4	0.94 871 8	0.45 882 4	321 752	0.189821	340	340
1_6 2	#d5 0b8 2	0.83 529 4	0.04 313 7	0.50 980 4	0.90 181 5	0.94 835 7	0.83 529 4	268 478	0.158391	324	320
1_6 2	#4a 071 9	0.29 019 6	0.02 745 1	0.09 803 9	0.95 522 4	0.90 540 5	0.29 019 6	222 060	0.131007	343	340
1_6 2	#7b 2e4 9	0.48 235 3	0.18 039 2	0.28 627 5	0.94 155 8	0.62 601 6	0.48 235 3	209 604	0.123658	338	335

1_6 2	#eb 40a 3	0.92 156 9	0.25 098	0.63 921 6	0.90 350 9	0.72 766	0.92 156 9	150 975	0.089069	325	325
1_6 2	#cb 8cb 3	0.79 607 8	0.54 902	0.70 196 1	0.89 682 5	0.31 034 5	0.79 607 8	284 34	0.016775	322	320
1_6 7	#c9 61a e	0.78 823 5	0.38 039 2	0.68 235 3	0.87 660 3	0.51 741 3	0.78 823 5	764 430	0.012409	315	315
1_6 7	#c7 84b b	0.78 039 2	0.51 764 7	0.73 333 3	0.86 318 4	0.33 668 3	0.78 039 2	341 562	0.005545	310	310
1_6 7	#d1 9cc b	0.81 960 8	0.61 176 5	0.79 607 8	0.85 220 1	0.25 358 9	0.81 960 8	155 895	0.002531	306	305
1_6 7	#a0 286 a	0.62 745 1	0.15 686 3	0.41 568 6	0.90 833 3	0.75	0.62 745 1	592 032	0.00961	326	325
1_6 7	#6e 133 a	0.43 137 3	0.07 451	0.22 745 1	0.92 857 1	0.82 727 3	0.43 137 3	436 053	0.007078	334	330
1_6 7	#faf efc	0.98 039 2	0.99 607 8	0.98 823 5	0.41 666 7	0.01 574 8	0.99 607 8	211 635	0.003435	150	150
1_6 7	#e7 9bd 8	0.90 588 2	0.60 784 3	0.84 705 9	0.86 622 8	0.32 900 4	0.90 588 2	193 422	0.00314	311	310
1_6 7	#df dfdf	0.87 451	0.87 451	0.87 451	0	0	0.87 451	576 702 99	0.936159	0	0
1_6 7	#dd 7ec 7	0.86 666 7	0.49 411 8	0.78 039 2	0.87 193	0.42 986 4	0.86 666 7	376 260	0.006108	313	310
1_6 7	#b9 469 1	0.72 549	0.27 451	0.56 862 7	0.89 130 4	0.62 162 2	0.72 549	861 484	0.013984	320	320
1_0 7	#f8f dfc	0.97 254 9	0.99 215 7	0.98 823 5	0.46 666 7	0.01 976 3	0.99 215 7	869 91	0.021779	168	165
1_0 7	#71 0d5 6	0.44 313 7	0.05 098	0.33 725 5	0.87 833 3	0.88 495 6	0.44 313 7	671 390	0.168091	316	315

1_0 7	#88 197 7	0.53 333 3	0.09 803 9	0.46 666 7	0.85 885 9	0.81 617 6	0.53 333 3	655 533	0.164121	309	305
1_0 7	#5a 0a3 7	0.35 294 1	0.03 921 6	0.21 568 6	0.90 625	0.88 888 9	0.35 294 1	580 379	0.145305	326	325
1_0 7	#ad 5aa 1	0.67 843 1	0.35 294 1	0.63 137 3	0.85 743	0.47 976 9	0.67 843 1	194 472	0.048688	308	305
1_0 7	#79 2e6 4	0.47 451	0.18 039 2	0.39 215 7	0.88	0.61 983 5	0.47 451	504 180	0.126228	316	315
1_0 7	#37 071 b	0.21 568 6	0.02 745 1	0.10 588 2	0.93 055 6	0.87 272 7	0.21 568 6	400 423	0.100251	335	335
1_0 7	#96 388 a	0.58 823 5	0.21 960 8	0.54 117 6	0.85 461	0.62 666 7	0.58 823 5	720 084	0.180282	307	305
1_0 7	#fdf bfc	0.99 215 7	0.98 431 4	0.98 823 5	0.91 666 7	0.00 790 5	0.99 215 7	180 759	0.045255	329	325
1_7 1a	#7d 0d4 2	0.49 019 6	0.05 098	0.25 882 4	0.92 113 1	0.89 6	0.49 019 6	768 627	0.101606	331	330
1_7 1a	#d0 6ab 3	0.81 568 6	0.41 568 6	0.70 196 1	0.88 071 9	0.49 038 5	0.81 568 6	953 988	0.12611	317	315
1_7 1a	#ae 3f7f	0.68 235 3	0.24 705 9	0.49 803 9	0.90 390 4	0.63 793 1	0.68 235 3	128 145 3	0.169398	325	325
1_7 1a	#51 0c2 6	0.31 764 7	0.04 705 9	0.14 902	0.93 719 8	0.85 185 2	0.31 764 7	499 290	0.066002	337	335
1_7 1a	#bf 589 9	0.74 902	0.34 509 8	0.6	0.89 482 2	0.53 926 7	0.74 902	121 588 2	0.16073	322	320
1_7 1a	#8a 366 0	0.54 117 6	0.21 176 5	0.37 647 1	0.91 666 7	0.60 869 6	0.54 117 6	719 436	0.095104	330	330
1_7 1a	#d2 84b d	0.82 352 9	0.51 764 7	0.74 117 6	0.87 820 5	0.37 142 9	0.82 352 9	806 271	0.106583	316	315

1_7 1a	#e3 96d 0	0.89 019 6	0.58 823 5	0.81 568 6	0.87 445 9	0.33 920 7	0.89 019 6	598 632	0.079134	314	310
1_7 1a	#a0 156 4	0.62 745 1	0.08 235 3	0.39 215 7	0.90 527 6	0.86 875 1	0.62 745 1	721 177	0.095334	325	325
1_7 2	#91 035 0	0.56 862 7	0.01 176 5	0.31 372 5	0.90 962 4	0.97 931 7	0.56 862 7	304 155	0.185873	327	325
1_7 2	#73 274 4	0.45 098 1	0.15 294 1	0.26 666 7	0.93 640 4	0.66 087 1	0.45 098 1	138 798	0.084821	337	335
1_7 2	#c6 519 b	0.77 647 1	0.31 764 7	0.60 784 3	0.89 458 7	0.59 090 9	0.77 647 1	948 33	0.057954	322	320
1_7 2	#48 091 c	0.28 235 3	0.03 529 4	0.10 980 4	0.94 973 5	0.87 5 1	0.28 235 3	230 266	0.140719	341	340
1_7 2	#9d 306 5	0.61 568 6	0.18 823 5	0.39 607 8	0.91 896 1	0.69 426 8	0.61 568 6	154 083	0.094162	330	330
1_7 2	#c0 85a b	0.75 294 1	0.52 156 9	0.67 058 8	0.89 265 5	0.30 729 2	0.75 294 1	381 06	0.023287	321	320
1_7 2	#c0 2a8 b	0.75 294 1	0.16 470 6	0.54 509 8	0.89 222 2	0.78 125 1	0.75 294 1	177 185	0.10828	321	320
1_7 2	#b3 067 3	0.70 196 1	0.02 352 9	0.45 098 1	0.89 499 1	0.96 648 1	0.70 196 1	225 205	0.137626	322	320
1_7 2	#71 033 0	0.44 313 7	0.01 176 5	0.18 823 5	0.93 181 8	0.97 345 1	0.44 313 7	273 725	0.167277	335	335
1_7 4	#b9 7dc 0	0.72 549 6	0.49 019 6	0.75 294 1	0.81 592 1	0.34 895 8	0.75 294 1	740 43	0.001362	293	290
1_7 4	#faf dfc	0.98 039 2	0.99 215 7	0.98 823 5	0.44 444 4	0.01 185 8	0.99 215 7	272 70	0.000502	160	160
1_7 4	#f3f 3f2	0.95 294 1	0.95 294 1	0.94 902 1	0.16 666 7	0.00 411 5	0.95 294 1	18	3.311046617 237033e_07	59	55

1_7 4	#f1f 1f1	0.94 509 8	0.94 509 8	0.94 509 8	0	0	0.94 509 8	534 492 51	0.983183	0	0
1_7 4	#af 5ba e	0.68 627 5	0.35 686 3	0.68 235 3	0.83 531 7	0.48	0.68 627 5	168 513	0.0031	300	300
1_7 4	#9a 3c8 b	0.60 392 2	0.23 529 4	0.54 509 8	0.85 992 9	0.61 039	0.60 392 2	166 020	0.003054	309	305
1_7 4	#faf 7f7	0.98 039 2	0.96 862 7	0.96 862 7	0	0.01 2	0.98 039 2	408 9	7.521594232 156792e_05	0	0
1_7 4	#50 0b2 c	0.31 372 5	0.04 313 7	0.17 254 9	0.92 029	0.86 25	0.31 372 5	233 319	0.004292	331	330
1_7 4	#eef df5	0.93 333 3	0.99 215 7	0.96 078 4	0.41 111 1	0.05 928 9	0.99 215 7	225	4.138808271 546291e_06	148	145
1_7 4	#7b 225 b	0.48 235 3	0.13 333 3	0.35 686 3	0.89 325 8	0.72 357 7	0.48 235 3	240 727	0.004428	321	320
1_7 6	#d3 d3d 3	0.82 745 1	0.82 745 1	0.82 745 1	0	0	0.82 745 1	608 096 82	0.932144	0	0
1_7 6	#b6 348 5	0.71 372 5	0.20 392 2	0.52 156 9	0.89 615 4	0.71 428 6	0.71 372 5	608 964	0.009335	322	320
1_7 6	#a6 126 a	0.65 098	0.07 058 8	0.41 568 6	0.90 090 1	0.89 156 6	0.65 098	562 183	0.008618	324	320
1_7 6	#6e 274 5	0.43 137 3	0.15 294 1	0.27 058 8	0.92 957 7	0.64 545 5	0.43 137 3	367 629	0.005635	334	330
1_7 6	#c4 519 c	0.76 862 7	0.31 764 7	0.61 176 5	0.89 130 4	0.58 673 5	0.76 862 7	475 044	0.007282	320	320
1_7 6	#93 366 4	0.57 647 1	0.21 176 5	0.39 215 7	0.91 756 3	0.63 265 3	0.57 647 1	532 995	0.00817	330	330
1_7 6	#a1 578 1	0.63 137 3	0.34 117 6	0.50 588 2	0.90 540 5	0.45 962 7	0.63 137 3	308 316	0.004726	325	325

1_7 6	#c9 79b 2	0.78 823 5	0.47 451	0.69 803 9	0.88 125	0.39 801	0.78 823 5	264 897	0.004061	317	315
1_7 6	#57 072 2	0.34 117 6	0.02 745 1	0.13 333 3	0.94 375	0.91 954	0.34 117 6	685 451	0.010507	339	335
1_7 6	#86 074 6	0.52 549	0.02 745 1	0.27 451	0.91 732 3	0.94 776 1	0.52 549	621 228	0.009523	330	330
1_7 8	#61 072 9	0.38 039 2	0.02 745 1	0.16 078 4	0.93 703 7	0.92 783 5	0.38 039 2	141 787 3	0.143243	337	335
1_7 8	#ba 5a9 b	0.72 941 2	0.35 294 1	0.60 784 3	0.88 715 3	0.51 612 9	0.72 941 2	130 941 0	0.132286	319	315
1_7 8	#41 071 8	0.25 490 2	0.02 745 1	0.09 411 8	0.95 114 9	0.89 230 8	0.25 490 2	604 017	0.061022	342	340
1_7 8	#ae 3b8 4	0.68 235 3	0.23 137 3	0.51 764 7	0.89 420 3	0.66 092	0.68 235 3	135 013 5	0.1364	321	320
1_7 8	#92 3d6 f	0.57 254 9	0.23 921 6	0.43 529 4	0.90 196 1	0.58 219 2	0.57 254 9	948 720	0.095846	324	320
1_7 8	#7d 044 1	0.49 019 6	0.01 568 6	0.25 490 2	0.91 597 8	0.96 8	0.49 019 6	138 193 6	0.139613	329	325
1_7 8	#77 274 e	0.46 666 7	0.15 294 1	0.30 588 2	0.91 875	0.67 226 9	0.46 666 7	100 664 1	0.101698	330	330
1_7 8	#9d 136 4	0.61 568 6	0.07 451	0.39 215 7	0.90 217 4	0.87 898 1	0.61 568 6	123 860 7	0.125133	324	320
1_7 8	#c5 7ba f	0.77 254 9	0.48 235 3	0.68 627 5	0.88 288 3	0.37 563 5	0.77 254 9	641 004	0.064759	317	315
1_7 9	#ab 329 7	0.67 058 8	0.19 607 8	0.59 215 7	0.86 088 2	0.70 760 2	0.67 058 8	642 888	0.092094	309	305
1_7 9	#92 067 8	0.57 254 9	0.02 352 9	0.47 058 8	0.86 428 6	0.95 890 4	0.57 254 9	928 598	0.133022	311	310

1_7 9	#91 587 f	0.56 862 7	0.34 509 8	0.49 803 9	0.88 596 5	0.39 310 3	0.56 862 7	178 509	0.025572	318	315
1_7 9	#64 244 5	0.39 215 7	0.14 117 6	0.27 058 8	0.91 406 3	0.64	0.39 215 7	522 792	0.07489	329	325
1_8 1	#a3 3a7 7	0.63 921 6	0.22 745 1	0.46 666 7	0.90 317 5	0.64 417 2	0.63 921 6	189 639	0.12749	325	325
1_8 1	#b4 127 8	0.70 588 2	0.07 058 8	0.47 058 8	0.89 506 2	0.9	0.70 588 2	132 805	0.089282	322	320
1_8 1	#78 073 5	0.47 058 8	0.02 745 1	0.20 784 3	0.93 215 3	0.94 166 7	0.47 058 8	261 035	0.175488	335	335
1_8 1	#be 419 3	0.74 509 8	0.25 490 2	0.57 647 1	0.89 066 7	0.65 789 5	0.74 509 8	164 139	0.110347	320	320
1_8 1	#50 091 e	0.31 372 5	0.03 529 4	0.11 764 7	0.95 070 4	0.88 75	0.31 372 5	135 157	0.090863	342	340
1_8 1	#fbf cfc	0.98 431 4	0.98 823 5	0.98 823 5	0.5	0.00 396 8	0.98 823 5	184 416	0.123979	180	180
1_8 1	#92 135 6	0.57 254 9	0.07 451	0.33 725 5	0.91 207 3	0.86 986 3	0.57 254 9	265 013	0.178163	328	325
1_8 1	#c2 60a 2	0.76 078 4	0.37 647 1	0.63 529 4	0.88 775 5	0.50 515 5	0.76 078 4	125 622	0.084453	319	315
1_8 1	#cc 8bb 9	0.8	0.54 509 8	0.72 549	0.88 205 1	0.31 862 7	0.8	296 52	0.019934	317	315
1_8 2	#5e 0b3 5	0.36 862 7	0.04 313 7	0.20 784 3	0.91 566 3	0.88 297 9	0.36 862 7	556 96	0.106075	329	325
1_8 2	#7d 125 4	0.49 019 6	0.07 058 8	0.32 941 2	0.89 719 6	0.85 6	0.49 019 6	375 60	0.071535	322	320
1_8 2	#b7 82b 9	0.71 764 7	0.50 980 4	0.72 549	0.82 727 3	0.29 729 7	0.72 549	450 21	0.085744	297	295

1_8 2	#3d 081 e	0.23 921 6	0.03 137 3	0.11 764 7	0.93 081 8	0.86 885 2	0.23 921 6	480 57	0.091527	335	335
1_8 2	#87 2c6 b	0.52 941 2	0.17 254 9	0.41 960 8	0.88 461 5	0.67 407 4	0.52 941 2	610 74	0.116318	318	315
1_8 2	#88 4b7 f	0.53 333 3	0.29 411 8	0.49 803 9	0.85 792 3	0.44 852 9	0.53 333 3	376 89	0.07178	308	305
1_8 2	#9b 398 e	0.60 784 3	0.22 352 9	0.55 686 3	0.85 544 2	0.63 225 8	0.60 784 3	915 69	0.174397	307	305
1_8 2	#a5 56a 3	0.64 705 9	0.33 725 5	0.63 921 6	0.83 755 3	0.47 878 8	0.64 705 9	118 743	0.226151	301	300
1_8 2	#64 2e4 b	0.39 215 7	0.18 039 2	0.29 411 8	0.91 049 4	0.54	0.39 215 7	296 52	0.056473	327	325
1_8 5	#b6 328 0	0.71 372 5	0.19 607 8	0.50 196 1	0.90 151 5	0.72 527 5	0.71 372 5	106 338	0.150607	324	320
1_8 5	#7e 224 b	0.49 411 8	0.13 333 3	0.29 411 8	0.92 572 5	0.73 015 9	0.49 411 8	326 28	0.046211	333	330
1_8 5	#8c 396 6	0.54 902	0.22 352 9	0.4	0.90 963 9	0.59 285 7	0.54 902	209 88	0.029725	327	325
1_8 5	#38 051 2	0.21 960 8	0.01 960 8	0.07 058 8	0.95 751 6	0.91 071 4	0.21 960 8	826 03	0.116991	344	340
1_8 5	#5d 052 2	0.36 470 6	0.01 960 8	0.13 333 3	0.94 507 6	0.94 623 7	0.36 470 6	124 066	0.175715	340	340
1_8 5	#a2 0b5 f	0.63 529 4	0.04 313 7	0.37 254 9	0.90 728 5	0.93 209 9	0.63 529 4	127 693	0.180852	326	325
1_8 5	#9a 578 7	0.60 392 2	0.34 117 6	0.52 941 2	0.88 059 7	0.43 506 5	0.60 392 2	144 51	0.020467	317	315
1_8 5	#7e 023 c	0.49 411 8	0.00 784 3	0.23 529 4	0.92 204 3	0.98 412 7	0.49 411 8	145 339	0.205844	331	330

1_8 5	#c1 649 e	0.75 686 3	0.39 215 7	0.61 960 8	0.89 605 7	0.48 186 5	0.75 686 3	519 57	0.073587	322	320
1_8 7	#af 217 f	0.68 627 5	0.12 941 2	0.49 803 9	0.88 967 1	0.81 142 9	0.68 627 5	254 278	0.08475	320	320
1_8 7	#a0 056 8	0.62 745 1	0.01 960 8	0.40 784 3	0.89 354 8	0.96 875 1	0.62 745 1	430 096	0.14335	321	320
1_8 7	#8b 035 0	0.54 509 8	0.01 176 5	0.31 372 5	0.90 563 7	0.97 841 7	0.54 509 8	421 579	0.140512	326	325
1_8 7	#5a 062 7	0.35 294 1	0.02 352 9	0.15 294 1	0.93 452 4	0.93 333 3	0.35 294 1	484 725	0.161558	336	335
1_8 7	#a5 427 e	0.64 705 9	0.25 882 4	0.49 411 8	0.89 899	0.6	0.64 705 9	242 049	0.080675	323	320
1_8 7	#3b 061 7	0.23 137 3	0.02 352 9	0.09 019 6	0.94 654 1	0.89 830 5	0.23 137 3	314 279	0.104749	340	340
1_8 7	#7d 2d5 5	0.49 019 6	0.17 647 1	0.33 333 3	0.91 666 7	0.64	0.49 019 6	251 874	0.083949	330	330
1_8 7	#73 043 b	0.45 098	0.01 568 6	0.23 137 3	0.91 741 7	0.96 521 7	0.45 098	432 194	0.144049	330	330
1_8 7	#bb 6ca 3	0.73 333 3	0.42 352 9	0.63 921 6	0.88 396 6	0.42 246	0.73 333 3	169 242	0.056408	318	315
1_8 8	#5b 0c3 e	0.35 686 3	0.04 705 9	0.24 313 7	0.89 451 5	0.86 813 2	0.35 686 3	659 271	0.213309	322	320
1_8 8	#af 7fb 2	0.68 627 5	0.49 803 9	0.69 803 9	0.82 352 9	0.28 651 7	0.69 803 9	355 29	0.011496	296	295
1_8 8	#85 207 a	0.52 156 9	0.12 549	0.47 843 1	0.85 148 5	0.75 939 8	0.52 156 9	505 135	0.163438	306	305
1_8 8	#72 115 e	0.44 705 9	0.06 666 7	0.36 862 7	0.86 769 8	0.85 087 7	0.44 705 9	674 566	0.218258	312	310

1_8 8	#36 091 f	0.21 176 5	0.03 529 4	0.12 156 9	0.91 851 9	0.83 333 3	0.21 176 5	368 268	0.119154	330	330
1_8 8	#89 408 6	0.53 725 5	0.25 098	0.52 549	0.84 018 3	0.53 284 7	0.53 725 5	303 198	0.098101	302	300
1_8 8	#71 396 4	0.44 313 7	0.22 352 9	0.39 215 7	0.87 202 4	0.49 557 5	0.44 313 7	257 682	0.083374	313	310
1_8 8	#9a 339 7	0.60 392 2	0.2	0.59 215 7	0.83 818 8	0.66 883 1	0.60 392 2	148 293	0.047981	301	300
1_8 8	#9c 599 c	0.61 176 5	0.34 902	0.61 176 5	0.83 333 3	0.42 948 7	0.61 176 5	138 744	0.044891	300	300
1_8 9	#bf cfc	0.98 431 4	0.98 823 5	0.98 823 5	0.5	0.00 396 8	0.98 823 5	230 808	0.087397	180	180
1_8 9	#8b 0f5 e	0.54 509 8	0.05 882 4	0.36 862 7	0.89 381 7	0.89 208 6	0.54 509 8	378 696	0.143396	321	320
1_8 9	#ae 429 1	0.68 235 3	0.25 882 4	0.56 862 7	0.87 808 6	0.62 069	0.68 235 3	295 896	0.112043	316	315
1_8 9	#71 0b3 e	0.44 313 7	0.04 313 7	0.24 313 7	0.91 666 7	0.90 265 5	0.44 313 7	455 292	0.1724	330	330
1_8 9	#31 061 5	0.19 215 7	0.02 352 9	0.08 235 3	0.94 186	0.87 755 1	0.19 215 7	209 198	0.079214	339	335
1_8 9	#8a 3a6 b	0.54 117 6	0.22 745 1	0.41 960 8	0.89 791 7	0.57 971	0.54 117 6	225 036	0.085212	323	320
1_8 9	#55 082 8	0.33 333 3	0.03 137 3	0.15 686 3	0.93 073 6	0.90 588 2	0.33 333 3	345 179	0.130705	335	335
1_8 9	#a6 177 b	0.65 098	0.09 019 6	0.48 235 3	0.88 345	0.86 144 6	0.65 098	377 051	0.142773	318	315
1_8 9	#ba 75a c	0.72 941 2	0.45 882 4	0.67 451	0.86 715	0.37 096 8	0.72 941 2	123 750	0.046859	312	310

1_9 1	#f5f cf5	0.96 078 4	0.98 823 5	0.96 078 4	0.33 333 3	0.02 777 8	0.98 823 5	129 39	0.002547	120	120
1_9 1	#faf efd	0.98 039 2	0.99 607 8	0.99 215 7	0.45 833 3	0.01 574 8	0.99 607 8	952 29	0.018748	165	165
1_9 1	#62 175 b	0.38 431 4	0.09 019 6	0.35 686 3	0.84 888 9	0.76 530 6	0.38 431 4	127 047 0	0.250119	305	305
1_9 1	#83 3f8 d	0.51 372 5	0.24 705 9	0.55 294 1	0.81 196 6	0.55 319 1	0.55 294 1	401 343	0.079013	292	290
1_9 1	#72 267 5	0.44 705 9	0.14 902	0.45 882 4	0.82 700 4	0.67 521 4	0.45 882 4	914 866	0.180111	297	295
1_9 1	#fef bfd	0.99 607 8	0.98 431 4	0.99 215 7	0.88 888 9	0.01 181 1	0.99 607 8	192 606	0.037919	319	315
1_9 1	#faf bf9	0.98 039 2	0.98 431 4	0.97 647 1	0.25	0.00 796 8	0.98 431 4	643 71	0.012673	90	90
1_9 1	#4f 093 e	0.30 980 4	0.03 529 4	0.24 313 7	0.87 381	0.88 607 6	0.30 980 4	111 372 5	0.219261	314	310
1_9 1	#2e 041 9	0.18 039 2	0.01 568 6	0.09 803 9	0.91 666 7	0.91 304 3	0.18 039 2	101 391 0	0.19961	330	330
1_9 1	#74 156 4	0.45 490 2	0.08 235 3	0.39 215 7	0.86 140 4	0.81 896 6	0.45 490 2	424 395	0.121174	310	310
1_9 1	#36 031 b	0.21 176 5	0.01 176 5	0.10 588 2	0.92 156 9	0.94 444 4	0.21 176 5	438 524	0.125208	331	330
1_9 1	#84 337 d	0.51 764 7	0.2	0.49 019 6	0.84 773 7	0.61 363 6	0.51 764 7	516 249	0.1474	305	305
1_9 1	#5b 074 1	0.35 686 3	0.02 745 1	0.25 490 2	0.88 492 1	0.92 307 7	0.35 686 3	675 894	0.192982	318	315
1_9 1	#93 479 1	0.57 647 1	0.27 843 1	0.56 862 7	0.83 771 9	0.51 700 7	0.57 647 1	435 339	0.124298	301	300

1_9 1_1	#67 215 2	0.40 392 2	0.12 941 2	0.32 156 9	0.88 333 3	0.67 961 2	0.40 392 2	374 289	0.106867	318	315
1_9 1_1	#76 336 8	0.46 274 5	0.2 941 2	0.40 784 3	0.86 815 9	0.56 779 7	0.46 274 5	303 606	0.086686	312	310
1_9 1_1	#85 4e8 0	0.52 156 9	0.30 588 2	0.50 196 1	0.84 848 5	0.41 353 4	0.52 156 9	192 948	0.055091	305	305
1_9 1_1	#9b 669 d	0.60 784 3	0.4 941 2	0.61 568 6	0.82 727 3	0.35 031 8	0.61 568 6	141 129	0.040295	297	295
2_1 0	#80 528 6	0.50 196 1	0.32 156 9	0.52 549 3	0.81 410 3	0.38 806 3	0.52 549 3	965 37	0.100322	293	290
2_1 0	#75 3b7 4	0.45 882 4	0.23 137 3	0.45 490 2	0.83 620 7	0.49 572 6	0.45 882 4	151 182	0.157109	301	300
2_1 0	#8c 659 2	0.54 902 2	0.39 607 8	0.57 254 9	0.81 111 1	0.30 821 9	0.57 254 9	372 84	0.038746	292	290
2_1 0	#43 082 8	0.26 274 5	0.03 137 3	0.15 686 3	0.90 960 5	0.88 059 7	0.26 274 5	107 442	0.111654	327	325
2_1 0	#8e 509 5	0.55 686 3	0.31 372 5	0.58 431 4	0.81 642 5	0.46 308 7	0.58 431 4	119 340	0.124018	293	290
2_1 0	#83 408 6	0.51 372 5	0.25 098 3	0.52 549 3	0.82 619 5	0.52 238 8	0.52 549 3	146 724	0.152476	297	295
2_1 0	#6d 235 e	0.42 745 1	0.13 725 5	0.36 862 7	0.86 711 7	0.67 889 9	0.42 745 1	133 706	0.138948	312	310
2_1 0	#9c 6fa 2	0.61 176 5	0.43 529 4	0.63 529 4	0.81 372 5	0.31 481 5	0.63 529 4	231 06	0.024012	292	290
2_1 0	#5c 114 1	0.36 078 4	0.06 666 7	0.25 490 2	0.89 333 3	0.81 521 7	0.36 078 4	146 955	0.152716	321	320
2_1 0	#7c 357 3	0.48 627 5	0.20 784 3	0.45 098 3	0.85 446 3	0.57 258 1	0.48 627 5	777 006	0.179174	307	305

2_1 0	#6a 205 7	0.41 568 6	0.12 549	0.34 117 6	0.87 612 6	0.69 811 3	0.41 568 6	840 009	0.193703	315	315
2_1 0	#91 609 8	0.56 862 7	0.37 647 1	0.59 607 8	0.81 25	0.36 842 1	0.59 607 8	469 221	0.1082	292	290
2_1 0	#4e 0c3 3	0.30 588 2	0.04 705 9	0.2	0.90 151 5	0.84 615 4	0.30 588 2	444 502	0.1025	324	320
2_1 0	#9e 4ca 4	0.61 960 8	0.29 803 9	0.64 313 7	0.82 197	0.53 658 5	0.64 313 7	464 361	0.10708	295	295
2_1 0	#8d 3f8 c	0.55 294 1	0.24 705 9	0.54 902	0.83 547	0.55 319 1	0.55 294 1	687 504	0.158536	300	300
2_1 0	#a5 8bb 7	0.64 705 9	0.54 509 8	0.71 764 7	0.76 515 2	0.24 043 7	0.71 764 7	614 01	0.014159	275	275
2_1 0	#aa 7bb d	0.66 666 7	0.48 235 3	0.74 117 6	0.78 535 4	0.34 920 6	0.74 117 6	135 747	0.031303	282	280
2_1 0	#a1 6aaf 3	0.63 137 3	0.41 568 6	0.68 627 5	0.79 951 7	0.39 428 6	0.68 627 5	456 840	0.105345	287	285
2_1 00	#7d 0c6 a	0.49 019 6	0.04 705 9	0.41 568 6	0.86 135 7	0.90 4	0.49 019 6	102 437 4	0.015988	310	310
2_1 00	#a1 419 d	0.63 137 3	0.25 490 2	0.61 568 6	0.84 027 8	0.59 627 3	0.63 137 3	495 219	0.007729	302	300
2_1 00	#ae 62a f	0.68 235 3	0.38 431 4	0.68 627 5	0.83 116 9	0.44	0.68 627 5	189 882	0.002964	299	295
2_1 00	#95 5a8 8	0.58 431 4	0.35 294 1	0.53 333 3	0.87 005 6	0.39 597 3	0.58 431 4	144 174	0.00225	313	310
2_1 00	#8e 2c8 2	0.55 686 3	0.17 254 9	0.50 980 4	0.85 374 1	0.69 014 1	0.55 686 3	106 447 1	0.016613	307	305
2_1 00	#64 064 a	0.39 215 7	0.02 352 9	0.29 019 6	0.87 943 3	0.94	0.39 215 7	139 236 2	0.021731	316	315

2_1 00	#b9 8cb 9	0.72 549	0.54 902	0.72 549	0.83 333 3	0.24 324 3	0.72 549	368 91	0.000576	300	300
2_1 00	#71 2b5 d	0.44 313 7	0.16 862 7	0.36 470 6	0.88 095 2	0.61 946 9	0.44 313 7	708 771	0.011062	317	315
2_1 00	#dd ddd d	0.86 666 7	0.86 666 7	0.86 666 7	0	0	0.86 666 7	581 058 78	0.906874	0	0
2_1 00	#48 072 c	0.28 235 3	0.02 745 1	0.17 254 9	0.90 512 8	0.90 277 8	0.28 235 3	910 701	0.014214	325	325
2_1 08	#faf efd	0.98 039 2	0.99 607 8	0.99 215 7	0.45 833 3	0.01 574 8	0.99 607 8	464 289	0.007127	165	165
2_1 08	#b7 308 d	0.71 764 7	0.18 823 5	0.55 294 1	0.88 518 5	0.73 770 5	0.71 764 7	100 052 9	0.015358	318	315
2_1 08	#92 0c6 1	0.57 254 9	0.04 705 9	0.38 039 2	0.89 427 9	0.91 780 8	0.57 254 9	359 729 9	0.055219	321	320
2_1 08	#bf 89a d	0.74 902	0.53 725 5	0.67 843 1	0.88 888 9	0.28 272 3	0.74 902	791 04	0.001214	320	320
2_1 08	#87 3b6 3	0.52 941 2	0.23 137 3	0.38 823 5	0.91 228 1	0.56 296 3	0.52 941 2	830 511	0.012749	328	325
2_1 08	#a4 367 c	0.64 313 7	0.21 176 5	0.48 627 5	0.89 393 9	0.67 073 2	0.64 313 7	105 288 9	0.016162	321	320
2_1 08	#64 053 2	0.39 215 7	0.01 960 8	0.19 607 8	0.92 105 3	0.95	0.39 215 7	343 145 4	0.052674	331	330
2_1 08	#a8 688 9	0.65 882 4	0.40 784 3	0.53 725 5	0.91 406 3	0.38 095 2	0.65 882 4	246 201	0.003779	329	325
2_1 08	#c1 58a 2	0.75 686 3	0.34 509 8	0.63 529 4	0.88 254	0.54 404 1	0.75 686 3	459 645	0.007056	317	315
2_1 08	#ee eee e	0.93 333 3	0.93 333 3	0.93 333 3	0	0	0.93 333 3	539 836 77	0.828662	0	0

2_1 27	#7d 034 6	0.49 019 6	0.01 176 5	0.27 451	0.90 847	0.97 6	0.49 019 6	133 788 5	0.198142	327	325
2_1 27	#a3 257 6	0.63 921 6	0.14 509 8	0.46 274 5	0.89 285 7	0.77 300 6	0.63 921 6	821 017	0.121593	321	320
2_1 27	#75 284 e	0.45 882 4	0.15 686 3	0.30 588 2	0.91 774 9	0.65 812	0.45 882 4	645 348	0.095577	330	330
2_1 27	#93 0d6 0	0.57 647 1	0.05 098	0.37 647 1	0.89 676 6	0.91 156 5	0.57 647 1	145 821 9	0.215963	322	320
2_1 27	#ae 438 8	0.68 235 3	0.26 274 5	0.53 333 3	0.89 252 3	0.61 494 3	0.68 235 3	374 388	0.055447	321	320
2_1 27	#90 396 a	0.56 470 6	0.22 352 9	0.41 568 6	0.90 613	0.60 416 7	0.56 470 6	658 365	0.097504	326	325
2_1 27	#39 041 2	0.22 352 9	0.01 568 6	0.07 058 8	0.95 597 5	0.92 982 5	0.22 352 9	424 829	0.062918	344	340
2_1 27	#5f 052 b	0.37 254 9	0.01 960 8	0.16 862 7	0.92 963	0.94 736 8	0.37 254 9	952 572	0.141077	334	330
2_1 27	#b5 6a9 8	0.70 980 4	0.41 568 6	0.59 607 8	0.89 777 8	0.41 436 5	0.70 980 4	795 33	0.011779	323	320
2_1 4	#3e 072 2	0.24 313 7	0.02 745 1	0.13 333 3	0.91 818 2	0.88 709 7	0.24 313 7	247 682	0.066691	330	330
2_1 4	#87 538 9	0.52 941 2	0.32 549	0.53 725 5	0.82 716	0.39 416 1	0.53 725 5	386 280	0.104009	297	295
2_1 4	#9a 5da 1	0.60 392 2	0.36 470 6	0.63 137 3	0.81 617 6	0.42 236	0.63 137 3	436 260	0.117467	293	290
2_1 4	#7d 317 4	0.49 019 6	0.19 215 7	0.45 490 2	0.85 307	0.60 8	0.49 019 6	791 508	0.213121	307	305
2_1 4	#8f 408 e	0.56 078 4	0.25 098	0.55 686 3	0.83 544 3	0.55 244 8	0.56 078 4	548 307	0.147637	300	300

2_1 4	#a3 7caf	0.63 921 6	0.48 627 5	0.68 627 5	0.79 411 8	0.29 142 9	0.68 627 5	113 442	0.030545	285	285
2_1 4	#6f 1c5 b	0.43 529 4	0.10 980 4	0.35 686 3	0.87 349 4	0.74 774 8	0.43 529 4	615 251	0.165662	314	310
2_1 4	#5d 053 f	0.36 470 6	0.01 960 8	0.24 705 9	0.89 015 2	0.94 623 7	0.36 470 6	349 280	0.094047	320	320
2_1 4	#55 213 e	0.33 333 3	0.12 941 2	0.24 313 7	0.90 705 1	0.61 176 5	0.33 333 3	225 885	0.060822	326	325
2_0 2	#75 044 3	0.45 882 4	0.01 568 6	0.26 274 5	0.90 708	0.96 581 2	0.45 882 4	634 137	0.157746	326	325
2_0 2	#51 072 5	0.31 764 7	0.02 745 1	0.14 509 8	0.93 243 2	0.91 358	0.31 764 7	502 163	0.124917	335	335
2_0 2	#aa 2f8 e	0.66 666 7	0.18 431 4	0.55 686 3	0.87 127 4	0.72 352 9	0.66 666 7	593 938	0.147746	313	310
2_0 2	#a4 558 9	0.64 313 7	0.33 333 3	0.53 725 5	0.89 029 5	0.48 170 7	0.64 313 7	212 865	0.052952	320	320
2_0 2	#bd 61a a	0.74 117 6	0.38 039 2	0.66 666 7	0.86 775 4	0.48 677 2	0.74 117 6	392 823	0.097718	312	310
2_0 2	#8e 0a6 f	0.55 686 3	0.03 921 6	0.43 529 4	0.87 247 5	0.92 957 7	0.55 686 3	565 775	0.140741	314	310
2_0 2	#9a 135 8	0.60 392 2	0.07 451	0.34 509 8	0.91 481 5	0.87 662 3	0.60 392 2	220 463	0.054842	329	325
2_0 2	#6d 274 b	0.42 745 1	0.15 294 1	0.29 411 8	0.91 428 6	0.64 220 2	0.42 745 1	330 978	0.082333	329	325
2_0 2	#8f 2f7 3	0.56 078 4	0.18 431 4	0.45 098	0.88 194 4	0.67 132 9	0.56 078 4	566 841	0.141006	317	315
2_2 0	#67 134 9	0.40 392 2	0.07 451	0.28 627 5	0.89 285 7	0.81 553 4	0.40 392 2	346 171	0.192329	321	320

2_2 0	#94 187 5	0.58 039 2	0.09 411 8	0.45 882 4	0.87 5	0.83 783 8	0.58 039 2	917 80	0.050992	315	315
2_2 0	#90 478 e	0.56 470 6	0.27 843 1	0.55 686 3	0.83 79	0.50 694 4	0.56 470 6	228 057	0.126706	301	300
2_2 0	#9c 2d8 b	0.61 176 5	0.17 647 1	0.54 509 8	0.85 885 9	0.71 153 8	0.61 176 5	125 517	0.069736	309	305
2_2 0	#44 092 7	0.26 666 7	0.03 529 4	0.15 294 1	0.91 525 4	0.86 764 7	0.26 666 7	287 454	0.159706	329	325
2_2 0	#7e 0f6 0	0.49 411 8	0.05 882 4	0.37 647 1	0.87 837 8	0.88 095 2	0.49 411 8	179 852	0.099924	316	315
2_2 0	#a7 65a d	0.65 490 2	0.39 607 8	0.67 843 1	0.81 944 4	0.41 618 5	0.67 843 1	156 528	0.086965	295	295
2_2 0	#80 317 3	0.50 196 1	0.19 215 7	0.45 098	0.86 075 9	0.61 718 8	0.50 196 1	234 642	0.130365	309	305
2_2 0	#a6 47a 1	0.65 098	0.27 843 1	0.63 137 3	0.84 210 5	0.57 228 9	0.65 098	149 889	0.083277	303	300
2_2 1	#79 135 6	0.47 451	0.07 451	0.33 725 5	0.89 052 3	0.84 297 5	0.47 451	137 358	0.076083	320	320
2_2 1	#a5 5a9 2	0.64 705 9	0.35 294 1	0.57 254 9	0.87 555 6	0.45 454 5	0.64 705 9	254 328	0.140873	315	315
2_2 1	#62 133 b	0.38 431 4	0.07 451	0.23 137 3	0.91 561 2	0.80 612 2	0.38 431 4	201 445	0.111581	329	325
2_2 1	#47 0a2 1	0.27 843 1	0.03 921 6	0.12 941 2	0.93 715 8	0.85 915 5	0.27 843 1	133 265	0.073816	337	335
2_2 1	#9a 3b8 0	0.60 392 2	0.23 137 3	0.50 196 1	0.87 894 7	0.61 688 3	0.60 392 2	227 840	0.126201	316	315
2_2 1	#89 2b6 7	0.53 725 5	0.16 862 7	0.40 392 2	0.89 361 7	0.68 613 1	0.53 725 5	243 078	0.134641	321	320

2_2 1	#74 2f5 2	0.45 490 2	0.18 431 4	0.32 156 9	0.91 545 9	0.59 482 8	0.45 490 2	175 731	0.097338	329	325
2_2 1	#8d 457 7	0.55 294 1	0.27 058 8	0.46 666 7	0.88 425 9	0.51 063 8	0.55 294 1	333 012	0.184456	318	315
2_2 1	#79 114 2	0.47 451	0.06 666 7	0.25 882 4	0.92 147 4	0.85 950 4	0.47 451	993 16	0.055011	331	330
2_2 2	#a1 508 1	0.63 137 3	0.31 372 5	0.50 588 2	0.89 917 7	0.50 310 6	0.63 137 3	342 138	0.049229	323	320
2_2 2	#7f 044 2	0.49 803 9	0.01 568 6	0.25 882 4	0.91 598 9	0.96 850 4	0.49 803 9	110 847 4	0.159493	329	325
2_2 2	#b8 3b9 2	0.72 156 9	0.23 137 3	0.57 254 9	0.88 4	0.67 934 8	0.72 156 9	101 130 9	0.145513	318	315
2_2 2	#b0 1b8 0	0.69 019 6	0.10 588 2	0.50 196 1	0.88 702 5	0.84 659 1	0.69 019 6	101 361 1	0.145844	319	315
2_2 2	#55 092 4	0.33 333 3	0.03 529 4	0.14 117 6	0.94 078 9	0.89 411 8	0.33 333 3	835 403	0.120202	338	335
2_2 2	#97 306 c	0.59 215 7	0.18 823 5	0.42 352 9	0.90 291 3	0.68 211 9	0.59 215 7	595 668	0.085708	325	325
2_2 2	#bd 6fa 7	0.74 117 6	0.43 529 4	0.65 490 2	0.88 034 2	0.41 269 8	0.74 117 6	338 370	0.048686	316	315
2_2 2	#6f 2c4 b	0.43 529 4	0.17 254 9	0.29 411 8	0.92 288 6	0.60 360 4	0.43 529 4	556 749	0.080108	332	330
2_2 2	#9d 056 4	0.61 568 6	0.01 960 8	0.39 215 7	0.89 583 3	0.96 815 3	0.61 568 6	114 825 6	0.165217	322	320
2_2 4	#af 76a e	0.68 627 5	0.46 274 5	0.68 235 3	0.83 625 7	0.32 571 4	0.68 627 5	981 15	0.001593	301	300
2_2 4	#d3 b2c d	0.82 745 1	0.69 803 9	0.80 392 2	0.86 363 6	0.15 639 8	0.82 745 1	135	2.192465182 516068e_06	310	310

2_2 4	#bf 9bb 9	0.74 902	0.60 784 3	0.72 549	0.86 111 1	0.18 848 2	0.74 902	564 3	9.164504462 917164e_05	310	310
2_2 4	#da dad a	0.85 490 2	0.85 490 2	0.85 490 2	0 0	0 0	0.85 490 2	588 629 10	0.955962	0	0
2_2 4	#a6 569 f	0.65 098	0.33 725 5	0.62 352 9	0.84 791 7	0.48 192 8	0.65 098	419 433	0.006812	305	305
2_2 4	#fbf bfb	0.98 431 4	0.98 431 4	0.98 431 4	0 0	0 0	0.98 431 4	999 36	0.001623	0	0
2_2 4	#7c 1a6 1	0.48 627 5	0.10 196 1	0.38 039 2	0.87 925 2	0.79 032 3	0.48 627 5	772 383	0.012544	316	315
2_2 4	#59 0d3 8	0.34 902	0.05 098	0.21 960 8	0.90 570 2	0.85 393 3	0.34 902	573 148	0.009308	326	325
2_2 4	#97 3a8 7	0.59 215 7	0.22 745 1	0.52 941 2	0.86 200 7	0.61 589 4	0.59 215 7	742 821	0.012064	310	310
2_2 5	#4b 082 b	0.29 411 8	0.03 137 3	0.16 862 7	0.91 293 5	0.89 333 3	0.29 411 8	305 983	0.227952	328	325
2_2 5	#a2 279 3	0.63 529 4	0.15 294 1	0.57 647 1	0.85 365 9	0.75 925 9	0.63 529 4	117 664	0.087658	307	305
2_2 5	#84 426 e	0.51 764 7	0.25 882 4	0.43 137 3	0.88 888 9	0.5 0	0.51 764 7	752 13	0.056032	320	320
2_2 5	#a4 5c8 f	0.64 313 7	0.36 078 4	0.56 078 4	0.88 194 4	0.43 902 4	0.64 313 7	420 18	0.031303	317	315
2_2 5	#b8 88b 9	0.72 156 9	0.53 333 3	0.72 549	0.82 993 2	0.26 486 5	0.72 549	322 65	0.024037	298	295
2_2 5	#8c 227 3	0.54 902	0.13 333 3	0.45 098	0.87 264 2	0.75 714 3	0.54 902	156 027	0.116238	314	310
2_2 5	#80 056 8	0.50 196 1	0.01 960 8	0.40 784 3	0.86 585 4	0.96 093 8	0.50 196 1	224 192	0.167019	311	310

2 5	#b3 4cb 0	0.70 196 1	0.29 803 9	0.69 019 6	0.83 818 8	0.57 541 9	0.70 196 1	556 59	0.041465	301	300
2 5	#6b 154 b	0.41 960 8	0.08 235 3	0.29 411 8	0.89 534 9	0.80 373 8	0.41 960 8	333 291	0.248296	322	320
2 7	#81 2d6 1	0.50 588 2	0.17 647 1	0.38 039 2	0.89 682 5	0.65 116 3	0.50 588 2	233 769	0.07298	322	320
2 7	#48 092 3	0.28 235 3	0.03 529 4	0.13 725 5	0.93 121 7	0.87 5	0.28 235 3	244 705	0.076394	335	335
2 7	#a2 439 9	0.63 529 4	0.26 274 5	0.6	0.84 912 3	0.58 642	0.63 529 4	546 609	0.170645	305	305
2 7	#6b 034 4	0.41 960 8	0.01 176 5	0.26 666 7	0.89 583 3	0.97 196 3	0.41 960 8	418 753	0.13073	322	320
2 7	#b2 66a e	0.69 803 9	0.4	0.68 235 3	0.84 210 5	0.42 696 6	0.69 803 9	203 883	0.06365	303	300
2 7	#84 0a6 8	0.51 764 7	0.03 921 6	0.40 784 3	0.87 158 5	0.92 424 2	0.51 764 7	507 848	0.158544	313	310
2 7	#61 264 1	0.38 039 2	0.14 902	0.25 490 2	0.92 372 9	0.60 824 7	0.38 039 2	215 931	0.067411	332	330
2 7	#95 298 3	0.58 431 4	0.16 078 4	0.51 372 5	0.86 111 1	0.72 483 2	0.58 431 4	656 566	0.204972	310	310
2 7	#88 4f7 e	0.53 333 3	0.30 980 4	0.49 411 8	0.86 257 3	0.41 911 8	0.53 333 3	175 137	0.054676	310	310
2 9	#65 033 d	0.39 607 8	0.01 176 5	0.23 921 6	0.90 136 1	0.97 029 7	0.39 607 8	612 453	0.108473	324	320
2 9	#44 061 f	0.26 666 7	0.02 352 9	0.12 156 9	0.93 279 6	0.91 176 5	0.26 666 7	517 952	0.091736	335	335
2 9	#5f 1d3 c	0.37 254 9	0.11 372 5	0.23 529 4	0.92 171 7	0.69 473 7	0.37 254 9	374 223	0.06628	331	330

2 9	#7b 0b5 e	0.48 235 3	0.04 313 7	0.36 862 7	0.87 648 8	0.91 056 9	0.48 235 3	884 252	0.156612	315	315
2 9	#6d 2f5 3	0.42 745 1	0.18 431 4	0.32 549	0.90 322 6	0.56 880 7	0.42 745 1	359 103	0.063602	325	325
2 9	#8c 1f7 9	0.54 902	0.12 156 9	0.47 451	0.86 238 5	0.77 857 1	0.54 902	939 303	0.166363	310	310
2 9	#97 3a8 a	0.59 215 7	0.22 745 1	0.54 117 6	0.85 663 1	0.61 589 4	0.59 215 7	984 507	0.174369	308	305
2 9	#a4 5c9 e	0.64 313 7	0.36 078 4	0.61 960 8	0.84 722 2	0.43 902 4	0.64 313 7	308 253	0.054596	305	305
2 9	#81 346 8	0.50 588 2	0.20 392 2	0.40 784 3	0.88 744 6	0.59 689 9	0.50 588 2	666 075	0.11797	319	315
2 3	#90 247 9	0.56 470 6	0.14 117 6	0.47 451	0.86 882 7	0.75	0.56 470 6	322 339	0.115844	312	310
2 3	#ac 77b 3	0.67 451	0.46 666 7	0.70 196 1	0.81 388 9	0.33 519 6	0.70 196 1	305 088	0.109644	293	290
2 3	#73 105 1	0.45 098	0.06 274 5	0.31 764 7	0.89 057 2	0.86 087	0.45 098	383 249	0.137734	320	320
2 3	#52 113 0	0.32 156 9	0.06 666 7	0.18 823 5	0.92 051 3	0.79 268 3	0.32 156 9	316 841	0.113868	331	330
2 3	#73 305 c	0.45 098	0.18 823 5	0.36 078 4	0.89 054 7	0.58 260 9	0.45 098	304 803	0.109542	320	320
2 3	#84 507 7	0.51 764 7	0.31 372 5	0.46 666 7	0.87 5	0.39 393 9	0.51 764 7	156 540	0.056258	315	315
2 3	#94 408 b	0.58 039 2	0.25 098	0.54 509 8	0.85 119	0.56 756 8	0.58 039 2	308 355	0.110818	306	305
2 3	#9e 60a 2	0.61 960 8	0.37 647 1	0.63 529 4	0.82 323 2	0.40 740 7	0.63 529 4	369 033	0.132625	296	295

2_0 3	#a5 469 f	0.64 705 9	0.27 451	0.62 352 9	0.84 386	0.57 575 8	0.64 705 9	316 278	0.113666	303	300
2_3 1	#8f 097 9	0.56 078 4	0.03 529 4	0.47 451	0.86 069 7	0.93 706 3	0.56 078 4	900 567	0.13793	309	305
2_3 1	#78 045 a	0.47 058 8	0.01 568 6	0.35 294 1	0.87 643 7	0.96 666 7	0.47 058 8	985 367	0.150918	315	315
2_3 1	#57 073 4	0.34 117 6	0.02 745 1	0.20 392 2	0.90 625	0.91 954	0.34 117 6	124 150 9	0.190148	326	325
2_3 1	#34 051 7	0.20 392 2	0.01 960 8	0.09 019 6	0.93 617	0.90 384 6	0.20 392 2	874 519	0.13394	337	335
2_3 1	#a3 199 4	0.63 921 6	0.09 803 9	0.58 039 2	0.85 144 9	0.84 662 6	0.63 921 6	750 763	0.114986	306	305
2_3 1	#8c 377 5	0.54 902	0.21 568 6	0.45 882 4	0.87 843 1	0.60 714 3	0.54 902	435 465	0.066695	316	315
2_3 1	#b3 7db 2	0.70 196 1	0.49 019 6	0.69 803 9	0.83 642	0.30 167 6	0.70 196 1	112 593	0.017245	301	300
2_3 1	#6a 224 c	0.41 568 6	0.13 333 3	0.29 803 9	0.90 277 8	0.67 924 5	0.41 568 6	691 131	0.105853	325	325
2_3 1	#b1 3aa 8	0.69 411 8	0.22 745 1	0.65 882 4	0.84 593 8	0.67 231 6	0.69 411 8	537 252	0.082285	304	300
2_3 4	#7b 2b5 6	0.48 235 3	0.16 862 7	0.33 725 5	0.91 041 7	0.65 040 7	0.48 235 3	305 433	0.005019	327	325
2_3 4	#87 446 a	0.52 941 2	0.26 666 7	0.41 568 6	0.90 547 3	0.49 629 6	0.52 941 2	271 557	0.004462	325	325
2_3 4	#5f 263 f	0.37 254 9	0.14 902	0.24 705 9	0.92 690 1	0.6 254 9	0.37 254 9	234 042	0.003846	333	330
2_3 4	#a5 549 2	0.64 705 9	0.32 941 2	0.57 254 9	0.87 242 8	0.49 090 9	0.64 705 9	425 142	0.006986	314	310

2_3 4	#40 0a1 f	0.25 098	0.03 921 6	0.12 156 9	0.93 518 5	0.84 375	0.25 098	165 487	0.002719	336	335
2_3 4	#91 176 8	0.56 862 7	0.09 019 6	0.40 784 3	0.88 934 4	0.84 137 9	0.56 862 7	211 479	0.003475	320	320
2_3 4	#de ded e	0.87 058 8	0.87 058 8	0.87 058 8	0 0	0 0	0.87 058 8	580 034 46	0.953076	0	0
2_3 4	#6f 083 d	0.43 529 4	0.03 137 3	0.23 921 6	0.91 423 9	0.92 792 8	0.43 529 4	242 849	0.00399	329	325
2_3 4	#b6 6ba f	0.71 372 5	0.41 960 8	0.68 627 5	0.84 888 9	0.41 208 8	0.71 372 5	593 619	0.009754	305	305
2_3 4	#a0 348 7	0.62 745 1	0.20 392 2	0.52 941 2	0.87 191 4	0.67 5	0.62 745 1	406 158	0.006674	313	310
2_3 8	#8d 4a7 1	0.55 294 1	0.29 019 6	0.44 313 7	0.90 298 5	0.47 517 7	0.55 294 1	493 602	0.113089	325	325
2_3 8	#7e 265 2	0.49 411 8	0.14 902	0.32 156 9	0.91 666 7	0.69 841 3	0.49 411 8	581 043	0.133122	330	330
2_3 8	#a0 6b9 0	0.62 745 1	0.41 960 8	0.56 470 6	0.88 364 8	0.33 125	0.62 745 1	302 238	0.069246	318	315
2_3 8	#9e 2f7 b	0.61 960 8	0.18 431 4	0.48 235 3	0.88 588 6	0.70 253 2	0.61 960 8	313 298	0.07178	318	315
2_3 8	#ae 6ca 4	0.68 235 3	0.42 352 9	0.64 313 7	0.85 858 6	0.37 931	0.68 235 3	531 276	0.12172	309	305
2_3 8	#a5 538 f	0.64 705 9	0.32 549	0.56 078 4	0.87 804 9	0.49 697	0.64 705 9	585 402	0.134121	316	315
2_3 8	#bd 91b c	0.74 117 6	0.56 862 7	0.73 725 5	0.83 712 1	0.23 280 4	0.74 117 6	433 686	0.099362	301	300
2_3 8	#5e 103 0	0.36 862 7	0.06 274 5	0.18 823 5	0.93 162 4	0.82 978 7	0.36 862 7	458 831	0.105123	335	335

2_3 8	#b3 7faf	0.70 196 1	0.49 803 9	0.68 627 5	0.84 615 4	0.29 050 3	0.70 196 1	665 349	0.152438	304	300
2_3 9	#87 167 6	0.52 941 2	0.08 627 5	0.46 274 5	0.85 840 7	0.83 703 7	0.52 941 2	224 236	0.228028	309	305
2_3 9	#9e 668 3	0.61 960 8	0.4	0.51 372 5	0.91 369	0.35 443	0.61 960 8	143 34	0.014576	328	325
2_3 9	#43 082 0	0.26 274 5	0.03 137 3	0.12 549	0.93 220 3	0.88 059 7	0.26 274 5	786 35	0.079965	335	335
2_3 9	#7e 366 7	0.49 411 8	0.21 176 5	0.40 392 2	0.88 657 4	0.57 142 9	0.49 411 8	733 32	0.074572	319	315
2_3 9	#76 0b5 4	0.46 274 5	0.04 313 7	0.32 941 2	0.88 629 3	0.90 678	0.46 274 5	163 751	0.16652	319	315
2_3 9	#95 2f8 8	0.58 431 4	0.18 431 4	0.53 333 3	0.85 457 5	0.68 456 4	0.58 431 4	177 873	0.180881	307	305
2_3 9	#5f 0e3 9	0.37 254 9	0.05 490 2	0.22 352 9	0.91 152 3	0.85 263 2	0.37 254 9	155 679	0.158311	328	325
2_3 9	#9f 489 a	0.62 352 9	0.28 235 3	0.60 392 2	0.84 291 2	0.54 717	0.62 352 9	777 33	0.079047	303	300
2_3 9	#af 77a 7	0.68 627 5	0.46 666 7	0.65 490 2	0.85 714 3	0.32	0.68 627 5	177 99	0.0181	308	305
2_0 4	#79 325 a	0.47 451	0.19 607 8	0.35 294 1	0.90 610 3	0.58 677 7	0.47 451	250 50	0.105045	326	325
2_0 4	#5e 0c3 5	0.36 862 7	0.04 705 9	0.20 784 3	0.91 666 7	0.87 234	0.36 862 7	514 94	0.215936	330	330
2_0 4	#8e 357 7	0.55 686 3	0.20 784 3	0.46 666 7	0.87 640 4	0.62 676 1	0.55 686 3	374 79	0.157165	315	315
2_0 4	#82 175 e	0.50 980 4	0.09 019 6	0.36 862 7	0.88 940 8	0.82 307 7	0.50 980 4	528 81	0.221752	320	320

2_0 4	#ac 5a9 3	0.67 451	0.35 294 1	0.57 647 1	0.88 414 6	0.47 674 4	0.67 451	152 19	0.06382	318	315
2_0 4	#ac 346 e	0.67 451	0.20 392 2	0.43 137 3	0.91 944 4	0.69 767 4	0.67 451	123 81	0.051919	331	330
2_0 4	#c0 63b 3	0.75 294 1	0.38 823 5	0.70 196 1	0.85 663 1	0.48 437 5	0.75 294 1	849 9	0.03564	308	305
2_0 4	#9b 498 8	0.60 784 3	0.28 627 5	0.53 333 3	0.87 195 1	0.52 903 2	0.60 784 3	297 21	0.124633	313	310
2_0 4	#ba 79a 1	0.72 941 2	0.47 451	0.63 137 3	0.89 743 6	0.34 946 2	0.72 941 2	574 5	0.024091	323	320
2_4 0	#b1 2d7 1	0.69 411 8	0.17 647 1	0.44 313 7	0.91 414 1	0.74 576 3	0.69 411 8	263 682	0.103461	329	325
2_4 0	#55 0b2 2	0.33 333 3	0.04 313 7	0.13 333 3	0.94 819 8	0.87 058 8	0.33 333 3	283 752	0.111336	341	340
2_4 0	#c7 2a8 d	0.78 039 2	0.16 470 6	0.55 294 1	0.89 490 4	0.78 894 5	0.78 039 2	319 347	0.125303	322	320
2_4 0	#ca 83b 3	0.79 215 7	0.51 372 5	0.70 196 1	0.88 732 4	0.35 148 5	0.79 215 7	154 896	0.060777	319	315
2_4 0	#84 073 e	0.51 764 7	0.02 745 1	0.24 313 7	0.92 666 7	0.94 697 7	0.51 764 7	379 299	0.148826	333	330
2_4 0	#cc 56a 5	0.8 725 5	0.33 725 5	0.64 705 9	0.88 841 8	0.57 843 1	0.8	293 085	0.114998	319	315
2_4 0	#83 345 5	0.51 372 5	0.20 392 2	0.33 333 3	0.93 038	0.60 305 3	0.51 372 5	154 335	0.060557	334	330
2_4 0	#b7 568 f	0.71 764 7	0.33 725 5	0.56 078 4	0.90 206 2	0.53 005 5	0.71 764 7	233 109	0.091465	324	320
2_4 0	#aa 066 6	0.66 666 7	0.02 352 9	0.4	0.90 243 9	0.96 470 6	0.66 666 7	467 101	0.183277	324	320

2_4 1	#9b 2a7 f	0.60 784 3	0.16 470 6	0.49 803 9	0.87 463 1	0.72 903 2	0.60 784 3	358 011	0.118251	314	310
2_4 1	#84 2b6 7	0.51 764 7	0.16 862 7	0.40 392 2	0.88 764 2	0.67 424 2	0.51 764 7	305 343	0.100855	319	315
2_4 1	#a9 449 c	0.66 274 5	0.26 666 7	0.61 176 5	0.85 478 5	0.59 763 3	0.66 274 5	533 781	0.176308	307	305
2_4 1	#92 4b8 6	0.57 254 9	0.29 411 8	0.52 549	0.86 150 2	0.48 630 1	0.57 254 9	272 898	0.090138	310	310
2_4 1	#47 0e2 8	0.27 843 1	0.05 490 2	0.15 686 3	0.92 397 7	0.80 281 7	0.27 843 1	277 843	0.091772	332	330
2_4 1	#6f 395 5	0.43 529 4	0.22 352 9	0.33 333 3	0.91 358	0.48 648 6	0.43 529 4	179 544	0.059303	328	325
2_4 1	#b3 68b 1	0.70 196 1	0.40 784 3	0.69 411 8	0.83 777 8	0.41 899 4	0.70 196 1	421 464	0.139209	301	300
2_4 1	#84 0c6 1	0.51 764 7	0.04 705 9	0.38 039 2	0.88 194 4	0.90 909 1	0.51 764 7	263 797	0.087132	317	315
2_4 1	#69 124 1	0.41 176 5	0.07 058 8	0.25 490 2	0.90 996 2	0.82 857 1	0.41 176 5	414 871	0.137032	327	325
2_4 3	#a5 075 c	0.64 705 9	0.02 745 1	0.36 078 4	0.91 033 8	0.95 757 6	0.64 705 9	432 392	0.007488	327	325
2_4 3	#bb 107 d	0.73 333 3	0.06 274 5	0.49 019 6	0.89 376 2	0.91 443 9	0.73 333 3	417 080	0.007223	321	320
2_4 3	#c5 349 2	0.77 254 9	0.20 392 2	0.57 254 9	0.89 195 4	0.73 604 1	0.77 254 9	589 482	0.010209	321	320
2_4 3	#84 043 8	0.51 764 7	0.01 568 6	0.21 960 8	0.93 229 2	0.96 969 7	0.51 764 7	400 591	0.006937	335	335
2_4 3	#d7 7db 7	0.84 313 7	0.49 019 6	0.71 764 7	0.89 259 3	0.41 860 5	0.84 313 7	248 721	0.004307	321	320

2_4 3	#d1 51a 6	0.81 960 8	0.31 764 7	0.65 098	0.88 932 3	0.61 244	0.81 960 8	574 851	0.009955	320	320
2_4 3	#a6 4a7 b	0.65 098	0.29 019 6	0.48 235 3	0.91 123 2	0.55 421 7	0.65 098	244 200	0.004229	328	325
2_4 3	#59 092 1	0.34 902	0.03 529 4	0.12 941 2	0.95	0.89 887 6	0.34 902	330 953	0.005731	342	340
2_4 3	#ed ede d	0.92 941 2	0.92 941 2	0.92 941 2	0	0	0.92 941 2	543 033 66	0.940423	0	0
2_4 3	#7b 324 e	0.48 235 3	0.19 607 8	0.30 588 2	0.93 607 3	0.59 349 6	0.48 235 3	201 897	0.003496	336	335
2_4 6	#ba 85b e	0.72 941 2	0.52 156 9	0.74 509 8	0.82 163 7	0.3	0.74 509 8	299 871	0.004679	295	295
2_4 6	#c7 9cc a	0.78 039 2	0.61 176 5	0.79 215 7	0.82 246 4	0.22 772 3	0.79 215 7	312 18	0.000487	296	295
2_4 6	#d6 b1d d	0.83 921 6	0.69 411 8	0.86 666 7	0.80 681 8	0.19 909 5	0.86 666 7	690	1.076603103 7593716e_0 5	290	290
2_4 6	#6b 214 9	0.41 960 8	0.12 941 2	0.28 627 5	0.90 991	0.69 158 9	0.41 960 8	620 183	0.009677	327	325
2_4 6	#8b 387 2	0.54 509 8	0.21 960 8	0.44 705 9	0.88 353 4	0.59 712 2	0.54 509 8	921 611	0.01438	318	315
2_4 6	#a2 519 7	0.63 529 4	0.31 764 7	0.59 215 7	0.85 596 7	0.5	0.63 529 4	107 539 5	0.016779	308	305
2_4 6	#ce b4d 0	0.80 784 3	0.70 588 2	0.81 568 6	0.82 142 9	0.13 461 5	0.81 568 6	164 1	2.560443033 723375e_05	295	295
2_4 6	#d5 d5d 5	0.83 529 4	0.83 529 4	0.83 529 4	0	0	0.83 529 4	603 301 80	0.941328	0	0
2_4 6	#b0 6bb 0	0.69 019 6	0.41 960 8	0.69 019 6	0.83 333 3	0.39 204 5	0.69 019 6	801 027	0.012498	300	300

2_4 6	#fef 3fd	0.99 607 8	0.95 294 1	0.99 215 7	0.84 848 5	0.04 330 7	0.99 607 8	865 5	0.000135	305	305
2_5 2	#b3 74b 6	0.70 196 1	0.45 490 2	0.71 372 5	0.82 575 8	0.36 263 7	0.71 372 5	353 796	0.127668	297	295
2_5 2	#61 224 2	0.38 039 2	0.13 333 3	0.25 882 4	0.91 534 4	0.64 948 5	0.38 039 2	209 859	0.075728	329	325
2_5 2	#9d 3e8 d	0.61 568 6	0.24 313 7	0.55 294 1	0.86 140 4	0.60 509 6	0.61 568 6	469 242	0.169327	310	310
2_5 2	#4d 0a2 9	0.30 196 1	0.03 921 6	0.16 078 4	0.92 288 6	0.87 013 1	0.30 196 1	203 199	0.073325	332	330
2_5 2	#73 0a5 0	0.45 098 0	0.03 921 6	0.31 372 5	0.88 888 9	0.91 304 3	0.45 098 0	330 528	0.119271	320	320
2_5 2	#bd 8ec 5	0.74 117 6	0.55 686 3	0.77 254 9	0.80 909 1	0.27 918 8	0.77 254 9	126 819	0.045763	291	290
2_5 2	#aa 5aa 6	0.66 666 7	0.35 294 1	0.65 098 0	0.84 166 7	0.47 058 8	0.66 666 7	408 192	0.147297	303	300
2_5 2	#7d 316 1	0.49 019 6	0.19 215 7	0.38 039 2	0.89 473 7	0.60 8 0	0.49 019 6	293 235	0.105814	322	320
2_5 2	#8e 217 6	0.55 686 3	0.12 941 2	0.46 274 5	0.87 003 1	0.76 760 6	0.55 686 3	376 355	0.135808	313	310
2_5 2	#68 264 6	0.40 784 3	0.14 902 0	0.27 451 0	0.91 919 2	0.63 461 5	0.40 784 3	480 465	0.092263	330	330
2_5 2	#b4 3d9 d	0.70 588 2	0.23 921 6	0.61 568 6	0.86 554 6	0.66 111 1	0.70 588 2	521 766	0.100193	311	310
2_5 2	#98 1a7 7	0.59 607 8	0.10 196 1	0.46 666 7	0.87 698 4	0.82 894 7	0.59 607 8	583 105	0.111972	315	315
2_5 2	#76 074 c	0.46 274 5	0.02 745 1	0.29 803 9	0.89 639 6	0.94 067 8	0.46 274 5	873 703	0.167775	322	320

2_5 2	#4d 082 7	0.30 196 1	0.03 137 3	0.15 294 1	0.92 512 1	0.89 610 4	0.30 196 1	849 566	0.16314	333	330
2_5 2	#97 418 7	0.59 215 7	0.25 490 2	0.52 941 2	0.86 434 1	0.56 953 6	0.59 215 7	479 685	0.092113	311	310
2_5 2	#83 2e6 5	0.51 372 5	0.18 039 2	0.39 607 8	0.89 215 7	0.64 885 5	0.51 372 5	523 668	0.100559	321	320
2_5 2	#a6 60a 6	0.65 098 6	0.37 647 1	0.65 098 3	0.83 333 3	0.42 168 7	0.65 098 4	472 452	0.090724	300	300
2_5 2	#be 7ab f	0.74 509 8	0.47 843 1	0.74 902 8	0.83 091 8	0.36 125 7	0.74 902 7	423 177	0.081262	299	295
2_6 3	#8d 457 6	0.55 294 1	0.27 058 8	0.46 274 5	0.88 657 4	0.51 063 8	0.55 294 1	186 306	0.121977	319	315
2_6 3	#98 4f8 d	0.59 607 8	0.30 980 4	0.55 294 1	0.85 844 7	0.48 026 3	0.59 607 8	139 557	0.09137	309	305
2_6 3	#ab 75a 8	0.67 058 8	0.45 882 4	0.65 882 4	0.84 259 3	0.31 578 9	0.67 058 8	182 607	0.119555	303	300
2_6 3	#6f 204 8	0.43 529 4	0.12 549	0.28 235 3	0.91 561 2	0.71 171 2	0.43 529 4	240 018	0.157143	329	325
2_6 3	#54 0e2 b	0.32 941 2	0.05 490 2	0.16 862 7	0.93 095 2	0.83 333 3	0.32 941 2	135 829	0.088929	335	335
2_6 3	#a0 5f8 3	0.62 745 1	0.37 254 9	0.51 372 5	0.90 769 2	0.40 625 1	0.62 745 1	588 21	0.038511	326	325
2_6 3	#80 336 2	0.50 196 1	0.2 431 4	0.38 826 8	0.89 156 3	0.60 196 1	0.50 824	243 824	0.159635	323	320
2_6 3	#a1 649 b	0.63 137 3	0.39 215 7	0.60 784 3	0.84 972 7	0.37 888 2	0.63 137 3	168 282	0.110176	305	305
2_6 3	#b3 8bb 8	0.70 196 1	0.54 509 8	0.72 156 9	0.81 481 5	0.24 456 5	0.72 156 9	172 143	0.112704	293	290

2_6 4	#d7 a60 a	0.84 313 7	0.65 098	0.03 921 6	0.12 682 9	0.95 348 8	0.84 313 7	7	2.332072459 490236e_06	45	45
2_6 4	#7f 043 b	0.49 803 9	0.01 568 6	0.23 137 3	0.92 547 4	0.96 850 4	0.49 803 9	470 095	0.156614	333	330
2_6 4	#4b 081 d	0.29 411 8	0.03 137 3	0.11 372 5	0.94 776 1	0.89 333 3	0.29 411 8	374 048	0.124615	341	340
2_6 4	#9f 045 d	0.62 352 9	0.01 568 6	0.36 470 6	0.90 430 1	0.97 484 3	0.62 352 9	511 504	0.170409	325	325
2_6 4	#6a 223 c	0.41 568 6	0.13 333 3	0.23 529 4	0.93 981 5	0.67 924 5	0.41 568 6	210 334	0.070073	338	335
2_6 4	#bb 087 c	0.73 333 3	0.03 137 3	0.48 627 5	0.89 199 3	0.95 721 9	0.73 333 3	401 444	0.133742	321	320
2_6 4	#bd 2e8 a	0.74 117 6	0.18 039 2	0.54 117 6	0.89 277 4	0.75 661 4	0.74 117 6	535 698	0.17847	321	320
2_6 4	#9b 2f6 8	0.60 784 3	0.18 431 4	0.40 784 3	0.91 203 7	0.69 677 4	0.60 784 3	291 246	0.09703	328	325
2_6 4	#ba 5c9 4	0.72 941 2	0.36 078 4	0.58 039 2	0.90 070 9	0.50 537 6	0.72 941 2	207 246	0.069045	324	320
2_6 9	#95 3c9 7	0.58 431 4	0.23 529 4	0.59 215 7	0.82 967 9	0.60 264 9	0.59 215 7	101 628	0.095284	298	295
2_6 9	#5b 0f4 0	0.35 686 3	0.05 882 4	0.25 098	0.89 254 4	0.83 516 5	0.35 686 3	195 423	0.183224	321	320
2_6 9	#70 0d5 f	0.43 921 6	0.05 098	0.37 254 9	0.86 195 3	0.88 392 9	0.43 921 6	167 304	0.156861	310	310
2_6 9	#73 285 e	0.45 098	0.15 686 3	0.36 862 7	0.88	0.65 217 4	0.45 098	991 89	0.092997	316	315
2_6 9	#83 388 5	0.51 372 5	0.21 960 8	0.52 156 9	0.82 900 4	0.57 894 7	0.52 156 9	111 948	0.10496	298	295

2_6 9	#8e 587 f	0.55 686 3	0.34 509 8	0.49 803 9	0.87 963	0.38 028 2	0.55 686 3	112 62	0.010559	316	315
2_6 9	#3e 0a2 2	0.24 313 7	0.03 921 6	0.13 333 3	0.92 307 7	0.83 871	0.24 313 7	163 326	0.153131	332	330
2_6 9	#9f 5aa 9	0.62 352 9	0.35 294 1	0.66 274 5	0.81 223 6	0.46 745 6	0.66 274 5	438 63	0.041125	292	290
2_6 9	#81 237 b	0.50 588 2	0.13 725 5	0.48 235 3	0.84 397 2	0.72 868 2	0.50 588 2	172 635	0.161859	303	300
2_0 7	#f9f efd	0.97 647 1	0.99 607 8	0.99 215 7	0.46 666 7	0.01 968 5	0.99 607 8	184 80	0.020925	168	165
2_0 7	#a7 67a d	0.65 490 2	0.40 392 2	0.67 843 1	0.81 904 8	0.40 462 4	0.67 843 1	636 66	0.072089	294	290
2_0 7	#faf af7	0.98 039 2	0.98 039 2	0.96 862 7	0.16 666 7	0.01 2	0.98 039 2	889 5	0.010072	59	55
2_0 7	#8c 278 1	0.54 902	0.15 294 1	0.50 588 2	0.85 148 5	0.72 142 9	0.54 902	203 062	0.229927	306	305
2_0 7	#fef bfd	0.99 607 8	0.98 431 4	0.99 215 7	0.88 888 9	0.01 181 1	0.99 607 8	333 18	0.037726	319	315
2_0 7	#65 154 1	0.39 607 8	0.08 235 3	0.25 490 2	0.90 833 3	0.79 207 9	0.39 607 8	154 726	0.175196	326	325
2_0 7	#7d 106 2	0.49 019 6	0.06 274 5	0.38 431 4	0.87 461 8	0.87 2	0.49 019 6	147 850	0.167411	314	310
2_0 7	#98 409 8	0.59 607 8	0.25 098	0.59 607 8	0.83 333 3	0.57 894 7	0.59 607 8	180 837	0.204762	300	300
2_0 7	#46 0d2 4	0.27 451	0.05 098	0.14 117 6	0.93 274 9	0.81 428 6	0.27 451	723 24	0.081892	335	335
2_7 0	#9e 559 5	0.61 960 8	0.33 333 3	0.58 431 4	0.85 388 1	0.46 202 5	0.61 960 8	325 446	0.005033	307	305

2_7 0	#7f 2d6 f	0.49 803 9	0.17 647 1	0.43 529 4	0.86 585 4	0.64 566 9	0.49 803 9	220 392 0	0.034086	311	310
2_7 0	#3f 072 4	0.24 705 9	0.02 745 1	0.14 117 6	0.91 369	0.88 888 9	0.24 705 9	515 235	0.007969	328	325
2_7 0	#74 106 0	0.45 490 2	0.06 274 5	0.37 647 1	0.86 666 7	0.86 206 9	0.45 490 2	229 784 4	0.035538	312	310
2_7 0	#e4 e4e 4	0.89 411 8	0.89 411 8	0.89 411 8	0	0	0.89 411 8	562 874 04	0.870533	0	0
2_7 0	#f4f bf7	0.95 686 3	0.98 431 4	0.96 862 7	0.40 476 2	0.02 788 8	0.98 431 4	191 67	0.000296	145	145
2_7 0	#92 398 8	0.57 254 9	0.22 352 9	0.53 333 3	0.85 206	0.60 958 9	0.57 254 9	125 201 1	0.019363	306	305
2_7 0	#5f 0b4 3	0.37 254 9	0.04 313 7	0.26 274 5	0.88 888 9	0.88 421 1	0.37 254 9	150 424 9	0.023265	320	320
2_7 0	#fbf bfc	0.98 431 4	0.98 431 4	0.98 823 5	0.66 666 7	0.00 396 8	0.98 823 5	253 266	0.003917	240	240
2_8 0	#68 0d5 b	0.40 784 3	0.05 098	0.35 686 3	0.85 714 3	0.87 5	0.40 784 3	195 215 6	0.175109	308	305
2_8 0	#37 052 3	0.21 568 6	0.01 960 8	0.13 725 5	0.9	0.90 909 1	0.21 568 6	147 044 5	0.1319	324	320
2_8 0	#76 146 f	0.46 274 5	0.07 843 1	0.43 529 4	0.84 523 8	0.83 050 8	0.46 274 5	129 548 2	0.116205	304	300
2_8 0	#56 044 2	0.33 725 5	0.01 568 6	0.25 882 4	0.87 398 4	0.95 348 8	0.33 725 5	195 749 1	0.175588	314	310
2_8 0	#83 2b8 3	0.51 372 5	0.16 862 7	0.51 372 5	0.83 333 3	0.67 175 6	0.51 372 5	151 091 1	0.135529	300	300
2_8 0	#74 2c6 e	0.45 490 2	0.17 254 9	0.43 137 3	0.84 722 2	0.62 069	0.45 490 2	143 316 6	0.128556	305	305

2_8 0	#93 5f9 d	0.57 647 1	0.37 254 9	0.61 568 6	0.80 645 2	0.39 490 4	0.61 568 6	142 440	0.012777	290	290
2_8 0	#59 254 a	0.34 902	0.14 509 8	0.29 019 6	0.88 141	0.58 427	0.34 902	594 285	0.053308	317	315
2_8 0	#8c 409 1	0.54 902	0.25 098	0.56 862 7	0.82 304 5	0.55 862 1	0.56 862 7	791 835	0.071028	296	295
2_8 2	#76 347 5	0.46 274 5	0.20 392 2	0.45 882 4	0.83 585 9	0.55 932 2	0.46 274 5	338 094	0.187817	300	300
2_8 2	#86 498 e	0.52 549	0.28 627 5	0.55 686 3	0.81 401	0.48 591 5	0.55 686 3	158 529	0.088066	293	290
2_8 2	#91 579 e	0.56 862 7	0.34 117 6	0.61 960 8	0.80 281 7	0.44 936 7	0.61 960 8	704 34	0.039127	289	285
2_8 2	#99 78a 7	0.6 058	0.47 058 8	0.65 490 2	0.78 368 8	0.28 143 7	0.65 490 2	102 24	0.00568	282	280
2_8 2	#5b 144 8	0.35 686 3	0.07 843 1	0.28 235 3	0.87 793 4	0.78 022	0.35 686 3	406 424	0.225775	316	315
2_8 2	#87 5f9 1	0.52 941 2	0.37 254 9	0.56 862 7	0.8 0	0.34 482 8	0.56 862 7	308 73	0.01715	288	285
2_8 2	#6b 216 2	0.41 960 8	0.12 941 2	0.38 431 4	0.85 360 4	0.69 158 9	0.41 960 8	374 102	0.20782	307	305
2_8 2	#41 0c2 9	0.25 490 2	0.04 705 9	0.16 078 4	0.90 880 5	0.81 538 5	0.25 490 2	174 334	0.096845	327	325
2_8 2	#81 3a8 5	0.50 588 2	0.22 745 1	0.52 156 9	0.82 444 4	0.56 391	0.52 156 9	237 111	0.131719	296	295
2_0 9	#a0 509 0	0.62 745 1	0.31 372 5	0.56 470 6	0.86 666 7	0.5 0	0.62 745 1	129 621	0.108278	312	310
2_0 9	#7d 045 f	0.49 019 6	0.01 568 6	0.37 254 9	0.87 465 6	0.96 8	0.49 019 6	106 096	0.088627	314	310

2_0 9	#45 092 2	0.27 058 8	0.03 529 4	0.13 333 3	0.93 055 6	0.86 956 5	0.27 058 8	229 413	0.191639	335	335
2_0 9	#97 238 0	0.59 215 7	0.13 725 5	0.50 196 1	0.86 637 9	0.76 821 2	0.59 215 7	862 13	0.072017	311	310
2_0 9	#85 3f6 d	0.52 156 9	0.24 705 9	0.42 745 1	0.89 047 6	0.52 631 6	0.52 156 9	977 40	0.081646	320	320
2_0 9	#77 235 1	0.46 666 7	0.13 725 5	0.31 764 7	0.90 873	0.70 588 2	0.46 666 7	144 393	0.120618	327	325
2_0 9	#65 063 c	0.39 607 8	0.02 352 9	0.23 529 4	0.90 526 3	0.94 059 4	0.39 607 8	163 210	0.136336	325	325
2_0 9	#5d 1f3 b	0.36 470 6	0.12 156 9	0.23 137 3	0.92 473	0.66 666 7	0.36 470 6	142 092	0.118696	332	330
2_0 9	#89 1e7 0	0.53 725 5	0.11 764 7	0.43 921 6	0.87 227 4	0.78 102 2	0.53 725 5	983 34	0.082143	314	310
2_9 4	#7b 2b5 7	0.48 235 3	0.16 862 7	0.34 117 6	0.90 833 3	0.65 040 7	0.48 235 3	162 735	0.075925	326	325
2_9 4	#9a 1e7 4	0.60 392 2	0.11 764 7	0.45 490 2	0.88 440 9	0.80 519 5	0.60 392 2	345 125	0.161019	318	315
2_9 4	#a0 3c8 5	0.62 745 1	0.23 529 4	0.52 156 9	0.87 833 3	0.62 5 5	0.62 745 1	208 881	0.097454	316	315
2_9 4	#8a 5c8 0	0.54 117 6	0.36 078 4	0.50 196 1	0.86 956 5	0.33 333 3	0.54 117 6	388 14	0.018109	313	310
2_9 4	#86 045 8	0.52 549 6	0.01 568 6	0.34 509 8	0.89 230 8	0.97 014 9	0.52 549	357 654	0.166865	321	320
2_9 4	#66 043 8	0.4 568 6	0.01 568 6	0.21 960 8	0.91 156 5	0.96 078 4	0.4 568 6	530 712	0.247606	328	325
2_9 4	#42 051 c	0.25 882 4	0.01 960 8	0.10 980 4	0.93 715 8	0.92 424 2	0.25 882 4	300 275	0.140094	337	335

2_9 4	#ab 629 9	0.67 058 8	0.38 431 4	0.6	0.87 442 9	0.42 690 1	0.67 058 8	503 40	0.023486	314	310
2_9 4	#fbf cfc	0.98 431 4	0.98 823 5	0.98 823 5	0.5	0.00 396 8	0.98 823 5	148 839	0.069441	180	180
2_9 8	#c0 499 8	0.75 294 1	0.28 627 5	0.59 607 8	0.88 935 6	0.61 979 2	0.75 294 1	271 293	0.004511	320	320
2_9 8	#ec ece c	0.92 549	0.92 549	0.92 549	0	0	0.92 549	544 339 32	0.905163	0	0
2_9 8	#e4 bcc 4	0.89 411 8	0.73 725 5	0.76 862 7	0.96 666 7	0.17 543 9	0.89 411 8	3	4.988597147 782884e_08	348	345
2_9 8	#c9 7cb 1	0.78 823 5	0.48 627 5	0.69 411 8	0.88 528 1	0.38 308 5	0.78 823 5	402 72	0.00067	318	315
2_9 8	#9a 076 2	0.60 392 2	0.02 745 1	0.38 431 4	0.89 682 5	0.95 454 5	0.60 392 2	150 918 2	0.025096	322	320
2_9 8	#7a 064 0	0.47 843 1	0.02 352 9	0.25 098	0.91 666 7	0.95 082	0.47 843 1	178 507 3	0.029683	330	330
2_9 8	#fcf bfb	0.98 823 5	0.98 431 4	0.98 431 4	0	0.00 396 8	0.98 823 5	223 569	0.003718	0	0
2_9 8	#aa 297 b	0.66 666 7	0.16 078 4	0.48 235 3	0.89 405 7	0.75 882 4	0.66 666 7	960 550	0.015973	321	320
2_9 8	#53 052 1	0.32 549	0.01 960 8	0.12 941 2	0.94 017 1	0.93 975 9	0.32 549	901 426	0.01499	338	335
2_9 8	#f3f bf7	0.95 294 1	0.98 431 4	0.96 862 7	0.41 666 7	0.03 187 3	0.98 431 4	118 47	0.000197	150	150
2_9 9	#39 081 d	0.22 352 9	0.03 137 3	0.11 372 5	0.92 857 1	0.85 964 9	0.22 352 9	117 921	0.104391	334	330
3_0 1	#a7 0e8 9	0.65 490 2	0.05 490 2	0.53 725 5	0.86 601 3	0.91 616 8	0.65 490 2	220 283	0.093204	311	310

3_0 1	#92 326 7	0.57 254 9	0.19 607 8	0.40 392 2	0.90 798 6	0.65 753 4	0.57 254 9	220 821	0.093432	326	325
3_0 1	#be 41a a	0.74 509 8	0.25 490 2	0.66 666 7	0.86	0.65 789 5	0.74 509 8	902 16	0.038171	309	305
3_0 1	#6d 284 6	0.42 745 1	0.15 686 3	0.27 451	0.92 753 6	0.63 302 8	0.42 745 1	291 633	0.123393	333	330
3_0 1	#bf 85b 6	0.74 902 9	0.52 156 9	0.71 372 5	0.85 919 5	0.30 366 5	0.74 902	222 66	0.009421	309	305
3_0 1	#a6 448 d	0.65 098	0.26 666 7	0.55 294 1	0.87 585	0.59 036 1	0.65 098	155 100	0.065625	315	315
3_0 1	#6e 034 2	0.43 137 3	0.01 176 5	0.25 882 4	0.90 186 9	0.97 272 7	0.43 137 3	444 358	0.188013	324	320
3_0 1	#48 072 2	0.28 235 3	0.02 745 1	0.13 333 3	0.93 076 9	0.90 277 8	0.28 235 3	559 039	0.236536	335	335
3_0 1	#8b 066 3	0.54 509 8	0.02 352 9	0.38 823 5	0.88 345 9	0.95 683 5	0.54 509 8	359 727	0.152205	318	315
3_1 0	#3d 112 3	0.23 921 6	0.06 666 7	0.13 725 5	0.93 181 8	0.72 131 1	0.23 921 6	128 332	0.022959	335	335
3_1 0	#5a 033 0	0.35 294 1	0.01 176 5	0.18 823 5	0.91 379 3	0.96 666 7	0.35 294 1	658 561	0.11782	328	325
3_1 0	#2b 040 f	0.16 862 7	0.01 568 6	0.05 882 4	0.95 299 1	0.90 697 7	0.16 862 7	204 298	0.03655	343	340
3_1 0	#7e 2c6 3	0.49 411 8	0.17 254 9	0.38 823 5	0.88 821 1	0.65 079 4	0.49 411 8	109 158 0	0.195289	319	315
3_1 0	#8b 477 b	0.54 509 8	0.27 843 1	0.48 235 3	0.87 254 9	0.48 920 9	0.54 509 8	100 176 0	0.17922	314	310
3_1 0	#46 021 b	0.27 451	0.00 784 3	0.10 588 2	0.93 872 5	0.97 142 9	0.27 451	417 872	0.074759	337	335

3_1 0	#69 255 0	0.41 176 5	0.14 509 8	0.31 372 5	0.89 460 8	0.64 761 9	0.41 176 5	727 221	0.130104	322	320
3_1 0	#6d 0b4 9	0.42 745 1	0.04 313 7	0.28 627 5	0.89 455 8	0.89 908 3	0.42 745 1	860 957	0.15403	322	320
3_1 0	#59 173 c	0.34 902	0.09 019 6	0.23 529 4	0.90 656 6	0.74 157 3	0.34 902	498 972	0.089269	326	325
3_1 0	#66 072 4	0.4 745	0.02 745 1	0.14 117 6	0.94 912 3	0.93 137 3	0.4	110 593 7	0.016787	341	340
3_1 0	#d1 91b a	0.81 960 8	0.56 862 7	0.72 941 2	0.89 322 9	0.30 622	0.81 960 8	639 81	0.000971	321	320
3_1 0	#43 051 2	0.26 274 5	0.01 960 8	0.07 058 8	0.96 505 4	0.92 537 3	0.26 274 5	691 687	0.010499	347	345
3_1 0	#dd 6ba d	0.86 666 7	0.41 960 8	0.67 843 1	0.90 350 9	0.51 583 7	0.86 666 7	156 762	0.002379	325	325
3_1 0	#d5 d5d 5	0.83 529 4	0.83 529 4	0.83 529 4	0 0	0 0	0.83 529 4	602 637 99	0.914728	0	0
3_1 0	#84 0a3 d	0.51 764 7	0.03 921 6	0.23 921 6	0.93 032 8	0.92 424 2	0.51 764 7	107 740 3	0.016354	334	330
3_1 0	#d7 449 2	0.84 313 7	0.26 666 7	0.57 254 9	0.91 156 5	0.68 372 1	0.84 313 7	408 573	0.006202	328	325
3_1 0	#8f 355 c	0.56 078 4	0.20 784 3	0.36 078 4	0.92 777 8	0.62 937 1	0.56 078 4	638 763	0.009696	334	330
3_1 0	#c8 1f7 a	0.78 431 4	0.12 156 9	0.47 843 1	0.91 025 6	0.84 5	0.78 431 4	601 067	0.009123	327	325
3_1 0	#aa 0b5 9	0.66 666 7	0.04 313 7	0.34 902	0.91 823 9	0.93 529 4	0.66 666 7	873 723	0.013262	330	330
3_1 00	#c4 438 e	0.76 862 7	0.26 274 5	0.55 686 3	0.90 310 1	0.65 816 3	0.76 862 7	115 959 6	0.167023	325	325

3_1 00	#90 064 4	0.56 470 6	0.02 352 9	0.26 666 7	0.92 512 1	0.95 833 3	0.56 470 6	785 353	0.113119	333	330
3_1 00	#e5 60a c	0.89 803 9	0.37 647 1	0.67 451	0.90 476 2	0.58 078 6	0.89 803 9	446 793	0.064354	325	325
3_1 00	#bf 709 f	0.74 902	0.43 921 6	0.62 352 9	0.90 084 4	0.41 361 3	0.74 902	358 494	0.051636	324	320
3_1 00	#94 366 2	0.58 039 2	0.21 176 5	0.38 431 4	0.92 198 6	0.63 513 5	0.58 039 2	654 990	0.094342	331	330
3_1 00	#ec 89c 3	0.92 549	0.53 725 5	0.76 470 6	0.90 235 7	0.41 949 2	0.92 549	350 787	0.050526	324	320
3_1 00	#be 247 f	0.74 509 8	0.14 117 6	0.49 803 9	0.90 151 5	0.81 052 6	0.74 509 8	135 570 8	0.19527	324	320
3_1 00	#5c 132 b	0.36 078 4	0.07 451	0.16 862 7	0.94 520 5	0.79 347 8	0.36 078 4	478 028	0.068853	340	340
3_1 00	#b1 066 9	0.69 411 8	0.02 352 9	0.41 176 5	0.90 350 9	0.96 610 2	0.69 411 8	135 298 9	0.194878	325	325
3_1 02	#8d 477 9	0.55 294 1	0.27 843 1	0.47 451	0.88 095 2	0.49 645 4	0.55 294 1	506 430	0.008615	317	315
3_1 02	#b9 69a 9	0.72 549	0.41 176 5	0.66 274 5	0.86 666 7	0.43 243 2	0.72 549	823 884	0.014016	312	310
3_1 02	#92 256 3	0.57 254 9	0.14 509 8	0.38 823 5	0.90 519 9	0.74 657 5	0.57 254 9	392 668	0.00668	325	325
3_1 02	#aa 3b8 5	0.66 666 7	0.23 137 3	0.52 156 9	0.88 888 9	0.65 294 1	0.66 666 7	386 790	0.00658	320	320
3_1 02	#a3 569 3	0.63 921 6	0.33 725 5	0.57 647 1	0.86 796 5	0.47 239 3	0.63 921 6	578 820	0.009847	312	310
3_1 02	#ed ede d	0.92 941 2	0.92 941 2	0.92 941 2	0 0	0 0	0.92 941 2	543 640 08	0.924816	0	0

3_1 02	#c8 87c 1	0.78 431 4	0.52 941 2	0.75 686 3	0.85 128 2	0.32 5	0.78 431 4	805 977	0.013711	306	305
3_1 02	#53 162 f	0.32 549	0.08 627 5	0.18 431 4	0.93 169 4	0.73 494	0.32 549	152 050	0.002587	335	335
3_1 02	#71 3a5 b	0.44 313 7	0.22 745 1	0.35 686 3	0.9	0.48 672 6	0.44 313 7	379 128	0.00645	324	320
3_1 02	#77 164 6	0.46 666 7	0.08 627 5	0.27 451	0.91 752 6	0.81 512 6	0.46 666 7	393 826	0.0067	330	330
3_1 5	#43 092 6	0.26 274 5	0.03 529 4	0.14 902	0.91 666 7	0.86 567 2	0.26 274 5	101 000 3	0.136041	330	330
3_1 5	#8a 548 7	0.54 117 6	0.32 941 2	0.52 941 2	0.84 259 3	0.39 130 4	0.54 117 6	762 381	0.102688	303	300
3_1 5	#9c 659 d	0.61 176 5	0.39 607 8	0.61 568 6	0.83 035 7	0.35 668 8	0.61 568 6	141 612	0.019074	298	295
3_1 5	#72 2b6 5	0.44 705 9	0.16 862 7	0.39 607 8	0.86 385	0.62 280 7	0.44 705 9	139 308 1	0.187639	310	310
3_1 5	#91 699 2	0.56 862 7	0.41 176 5	0.57 254 9	0.82 926 8	0.28 082 2	0.57 254 9	195 561	0.026341	298	295
3_1 5	#9f 7ea 3	0.62 352 9	0.49 411 8	0.63 921 6	0.81 531 5	0.22 699 4	0.63 921 6	708 39	0.009542	293	290
3_1 5	#5d 164 7	0.36 470 6	0.08 627 5	0.27 843 1	0.88 497 7	0.76 344 1	0.36 470 6	164 262 7	0.221251	318	315
3_1 5	#7d 437 5	0.49 019 6	0.26 274 5	0.45 882 4	0.85 632 2	0.46 4	0.49 019 6	139 289 7	0.187614	308	305
3_1 5	#64 325 7	0.39 215 7	0.19 607 8	0.34 117 6	0.87 666 7	0.5	0.39 215 7	815 268	0.109811	315	315
3_2 0	#70 335 6	0.43 921 6	0.2	0.33 725 5	0.90 437 2	0.54 464 3	0.43 921 6	516 69	0.06842	325	325

3_2 0	#a0 499 6	0.62 745 1	0.28 627 5	0.58 823 5	0.85 249	0.54 375	0.62 745 1	122 772	0.162575	306	305
3_2 0	#7a 094 d	0.47 843 1	0.03 529 4	0.30 196 1	0.89 970 5	0.92 623	0.47 843 1	403 16	0.053387	323	320
3_2 0	#90 317 1	0.56 470 6	0.19 215 7	0.44 313 7	0.88 771 9	0.65 972 2	0.56 470 6	109 346	0.144796	319	315
3_2 0	#c0 97d 4	0.75 294 1	0.59 215 7	0.83 137 3	0.77 868 9	0.28 773 6	0.83 137 3	684 60	0.090655	280	280
3_2 0	#18 0d1 6	0.09 411 8	0.05 098	0.08 627 5	0.86 363 6	0.45 833 3	0.09 411 8	778 7	0.010312	310	310
3_2 0	#b2 82c 6	0.69 803 9	0.50 980 4	0.77 647 1	0.78 431 4	0.34 343 4	0.77 647 1	151 581	0.200724	282	280
3_2 0	#ab 67b 6	0.67 058 8	0.40 392 2	0.71 372 5	0.81 012 7	0.43 406 6	0.71 372 5	172 506	0.228433	291	290
3_2 0	#52 163 3	0.32 156 9	0.08 627 5	0.2	0.91 944 4	0.73 170 7	0.32 156 9	307 35	0.040699	331	330
3_2 1	#bd 017 0	0.74 117 6	0.00 392 2	0.43 921 6	0.90 159 6	0.99 470 9	0.74 117 6	401 34	0.096155	324	320
3_2 1	#9e 356 0	0.61 960 8	0.20 784 3	0.37 647 1	0.93 174 6	0.66 455 7	0.61 960 8	499 65	0.119709	335	335
3_2 1	#65 0b3 0	0.39 607 8	0.04 313 7	0.18 823 5	0.93 148 1	0.89 108 9	0.39 607 8	822 15	0.196975	335	335
3_2 1	#a7 015 d	0.65 490 2	0.00 392 2	0.36 470 6	0.90 763 1	0.99 401 2	0.65 490 2	563 70	0.135054	326	325
3_2 1	#43 051 9	0.26 274 5	0.01 960 8	0.09 803 9	0.94 623 7	0.92 537 3	0.26 274 5	665 33	0.159403	340	340
3_2 1	#cb 027 d	0.79 607 8	0.00 784 3	0.49 019 6	0.89 801	0.99 014 8	0.79 607 8	104 14	0.02495	323	320

3_2 1	#87 054 1	0.52 941 2	0.01 960 8	0.25 490 2	0.92 307 7	0.96 296 3	0.52 941 2	745 66	0.178649	332	330
3_2 1	#a2 5b8 6	0.63 529 4	0.35 686 3	0.52 549	0.89 906 1	0.43 827 2	0.63 529 4	320 19	0.076713	323	320
3_2 1	#c1 2b8 7	0.75 686 3	0.16 862 7	0.52 941 2	0.89 777 8	0.77 720 2	0.75 686 3	517 2	0.012391	323	320
3_3 0	#52 152 e	0.32 156 9	0.08 235 3	0.18 039 2	0.93 169 4	0.74 390 2	0.32 156 9	291 41	0.098686	335	335
3_3 0	#63 204 0	0.38 823 5	0.12 549	0.25 098	0.92 039 8	0.67 676 8	0.38 823 5	273 69	0.092685	331	330
3_3 0	#a9 8a9 e	0.66 274 5	0.54 117 6	0.61 960 8	0.89 247 3	0.18 343 2	0.66 274 5	955 5	0.032358	321	320
3_3 0	#7c 2d6 e	0.48 627 5	0.17 647 1	0.43 137 3	0.86 286 9	0.63 709 7	0.48 627 5	590 67	0.200031	310	310
3_3 0	#5f 044 5	0.37 254 9	0.01 568 6	0.27 058 8	0.88 095 2	0.95 789 5	0.37 254 9	320 60	0.108572	317	315
3_3 0	#79 345 4	0.47 451	0.20 392 2	0.32 941 2	0.92 270 5	0.57 024 8	0.47 451	265 11	0.08978	332	330
3_3 0	#70 195 c	0.43 921 6	0.09 803 9	0.36 078 4	0.87 164 8	0.77 678 6	0.43 921 6	421 05	0.142589	313	310
3_3 0	#36 0b1 b	0.21 176 5	0.04 313 7	0.10 588 2	0.93 798 4	0.79 629 6	0.21 176 5	241 33	0.081727	337	335
3_3 0	#87 437 9	0.52 941 2	0.26 274 5	0.47 451	0.86 764 7	0.50 370 4	0.52 941 2	453 48	0.153572	312	310
3_3 3	#47 062 8	0.27 843 1	0.02 352 9	0.15 686 3	0.91 282 1	0.91 549 3	0.27 843 1	173 076 6	0.239358	328	325
3_3 3	#62 214 6	0.38 431 4	0.12 941 2	0.27 451	0.90 512 8	0.66 326 5	0.38 431 4	104 967 9	0.145166	325	325

3_3 3	#78 436 7	0.47 058 8	0.26 274 5	0.40 392 2	0.88 679 2	0.44 166 7	0.47 058 8	466 881	0.064568	319	315
3_3 3	#a1 74a 7	0.63 137 3	0.45 490 2	0.65 490 2	0.81 372 5	0.30 538 9	0.65 490 2	777 57	0.010753	292	290
3_3 3	#8e 318 6	0.55 686 3	0.19 215 7	0.52 549	0.84 767	0.65 493	0.55 686 3	852 353	0.117877	305	305
3_3 3	#9e 499 e	0.61 960 8	0.28 627 5	0.61 960 8	0.83 333 3	0.53 797 5	0.61 960 8	352 488	0.048748	300	300
3_3 3	#7c 216 c	0.48 627 5	0.12 941 2	0.42 352 9	0.86 263 7	0.73 387 1	0.48 627 5	118 949 1	0.164502	310	310
3_3 3	#8f 518 8	0.56 078 4	0.31 764 7	0.53 333 3	0.85 215 1	0.43 356 6	0.56 078 4	279 711	0.038683	306	305
3_3 3	#6b 065 4	0.41 960 8	0.02 352 9	0.32 941 2	0.87 128 7	0.94 392 5	0.41 960 8	123 173 7	0.170344	313	310
3_3 3	#36 0e1 e	0.21 176 5	0.05 490 2	0.11 764 7	0.93 333 3	0.74 074 1	0.21 176 5	138 521	0.002206	335	335
3_3 3	#63 0d3 7	0.38 823 5	0.05 098	0.21 568 6	0.91 860 5	0.86 868 7	0.38 823 5	370 856	0.005907	330	330
3_3 3	#9b 3c7 b	0.60 784 3	0.23 529 4	0.48 235 3	0.88 947 4	0.61 290 3	0.60 784 3	654 423	0.010424	320	320
3_3 3	#ba 359 9	0.72 941 2	0.20 784 3	0.6 468 7	0.87 505 4	0.71 941 2	0.72 248	756 248	0.012046	314	310
3_3 3	#9f 0c7 5	0.62 352 9	0.04 705 9	0.45 882 4	0.88 095 2	0.92 452 8	0.62 352 9	581 694	0.009266	317	315
3_3 3	#dd ddd d	0.86 666 7	0.86 666 7	0.86 666 7	0 0	0 0	0.86 666 7	580 785 09	0.925113	0	0
3_3 3	#d2 89c 5	0.82 352 9	0.53 725 5	0.77 254 9	0.86 301 4	0.34 761 9	0.82 352 9	265 443	0.004228	310	310

3 <sub>3</sub> 3	#80 185 6	0.50 196 1	0.09 411 8	0.33 725 5	0.90 064 1	0.81 25 1	0.50 196 1	579 630	0.009233	324	320
3 <sub>3</sub> 3	#cf 6bb e	0.81 176 5	0.41 960 8	0.74 509 8	0.86 166 7	0.48 309 2	0.81 176 5	569 601	0.009073	310	310
3 <sub>3</sub> 3	#c0 57a 8	0.75 294 1	0.34 117 6	0.65 882 4	0.87 142 9	0.54 687 5	0.75 294 1	784 953	0.012503	313	310
3 <sub>4</sub> 0	#73 065 a	0.45 098	0.02 352 9	0.35 294 1	0.87 156	0.94 782 6	0.45 098	108 439 6	0.185065	313	310
3 <sub>4</sub> 0	#ac 6caf	0.67 451	0.42 352 9	0.68 627 5	0.82 587 1	0.38 285 7	0.68 627 5	272 274	0.046467	297	295
3 <sub>4</sub> 0	#74 2e5 f	0.45 490 2	0.18 039 2	0.37 254 9	0.88 333 3	0.60 344 8	0.45 490 2	674 211	0.115062	318	315
3 <sub>4</sub> 0	#5e 033 c	0.36 862 7	0.01 176 5	0.23 529 4	0.89 560 4	0.96 808 5	0.36 862 7	770 324	0.131465	322	320
3 <sub>4</sub> 0	#5d 204 3	0.36 470 6	0.12 549	0.26 274 5	0.90 437 2	0.65 591 4	0.36 470 6	490 263	0.083669	325	325
3 <sub>4</sub> 0	#8e 398 0	0.55 686 3	0.22 352 9	0.50 196 1	0.86 078 4	0.59 859 2	0.55 686 3	734 643	0.125376	309	305
3 <sub>4</sub> 0	#88 197 8	0.53 333 3	0.09 803 9	0.47 058 8	0.85 735 7	0.81 617 6	0.53 333 3	864 860	0.147599	308	305
3 <sub>4</sub> 0	#a0 419 9	0.62 745 1	0.25 490 2	0.6 561 4	0.84 375 4	0.59 745 1	0.62 745 1	659 382	0.112531	304	300
3 <sub>4</sub> 0	#3f 0a2 3	0.24 705 9	0.03 921 6	0.13 725 5	0.92 138 4	0.84 127 9	0.24 705 9	309 187	0.052766	331	330
3 <sub>5</sub> 0	#3f 071 7	0.24 705 9	0.02 745 1	0.09 019 6	0.95 238 1	0.88 888 9	0.24 705 9	336 331	0.054273	342	340
3 <sub>5</sub> 0	#ae 4b8 c	0.68 235 3	0.29 411 8	0.54 902	0.89 057 2	0.56 896 6	0.68 235 3	120 186 6	0.193944	320	320

3_5 0	#5f 092 9	0.37 254 9	0.03 529 4	0.16 078 4	0.93 798 4	0.90 526 3	0.37 254 9	583 614	0.094177	337	335
3_5 0	#7c 054 1	0.48 627 5	0.01 960 8	0.25 490 2	0.91 596 6	0.95 967 7	0.48 627 5	540 199	0.087172	329	325
3_5 0	#7c 204 c	0.48 627 5	0.12 549	0.29 803 9	0.92 029	0.74 193 5	0.48 627 5	503 568	0.08126	331	330
3_5 0	#9b 3b7 5	0.60 784 3	0.23 137 3	0.45 882 4	0.89 930 6	0.61 935 5	0.60 784 3	123 384 6	0.199105	323	320
3_5 0	#77 395 b	0.46 666 7	0.22 352 9	0.35 686 3	0.90 860 2	0.52 100 8	0.46 666 7	372 441	0.060101	327	325
3_5 0	#98 196 3	0.59 607 8	0.09 803 9	0.38 823 5	0.90 288 7	0.83 552 6	0.59 607 8	764 073	0.123298	325	325
3_5 0	#b4 6d9 c	0.70 588 2	0.42 745 1	0.61 176 5	0.88 967 1	0.39 444 4	0.70 588 2	661 029	0.10667	320	320
3_5 4	#77 034 2	0.46 666 7	0.01 176 5	0.25 882 4	0.90 948 3	0.97 479	0.46 666 7	225 701 5	0.235503	327	325
3_5 4	#98 056 5	0.59 607 8	0.01 960 8	0.39 607 8	0.89 115 6	0.96 710 5	0.59 607 8	123 900 8	0.129282	320	320
3_5 4	#4e 042 0	0.30 588 2	0.01 568 6	0.12 549	0.93 693 7	0.94 871 8	0.30 588 2	204 473 2	0.213353	337	335
3_5 4	#97 527 b	0.59 215 7	0.32 156 9	0.48 235 3	0.90 096 6	0.45 695 4	0.59 215 7	416 856	0.043496	324	320
3_5 4	#86 285 c	0.52 549	0.15 686 3	0.36 078 4	0.90 780 1	0.70 149 3	0.52 549	879 825	0.091803	326	325
3_5 4	#b7 2f8 d	0.71 764 7	0.18 431 4	0.55 294 1	0.88 480 4	0.74 316 9	0.71 764 7	875 689	0.091372	318	315
3_5 4	#69 2a4 5	0.41 176 5	0.16 470 6	0.27 058 8	0.92 857 1	0.6	0.41 176 5	598 725	0.062473	334	330

3_5 4	#9e 277 5	0.61 960 8	0.15 294 1	0.45 882 4	0.89 075 6	0.75 316 5	0.61 960 8	846 645	0.088341	320	320
3_5 4	#b9 64a 2	0.72 549 8	0.39 215 7	0.63 529 4	0.87 843 1	0.45 945 9	0.72 549 8	425 298	0.044377	316	315
3_6 0	#62 084 c	0.38 431 4	0.03 137 3	0.29 803 9	0.87 407 4	0.91 836 7	0.38 431 4	557 721	0.2336	314	310
3_6 0	#7a 1f7 0	0.47 843 1	0.12 156 9	0.43 921 6	0.85 164 8	0.74 590 2	0.47 843 1	459 452	0.19244	306	305
3_6 0	#9e 6e9 e	0.61 960 8	0.43 137 3	0.61 960 8	0.83 333 3	0.30 379 7	0.61 960 8	289 50	0.012126	300	300
3_6 0	#96 4d9 7	0.58 823 5	0.30 196 1	0.59 215 7	0.83 108 1	0.49 006 6	0.59 215 7	111 072	0.046522	299	295
3_6 0	#a9 86a f	0.66 274 5	0.52 549 5	0.68 627 5	0.80 894 3	0.23 428 6	0.68 627 5	141 69	0.005935	291	290
3_6 0	#7e 477 6	0.49 411 8	0.27 843 1	0.46 274 5	0.85 757 6	0.43 650 8	0.49 411 8	145 578	0.060975	308	305
3_6 0	#6a 265 5	0.41 568 6	0.14 902 3	0.33 333 4	0.88 480 4	0.64 150 9	0.41 568 6	370 614	0.155231	318	315
3_6 0	#45 0a2 8	0.27 058 8	0.03 921 6	0.15 686 3	0.91 525 4	0.85 507 2	0.27 058 8	422 512	0.176968	329	325
3_6 0	#8a 338 5	0.54 117 6	0.2 156 9	0.52 156 9	0.84 291 2	0.63 043 5	0.54 117 6	277 434	0.116203	303	300
3_6 0	#3c 071 d	0.23 529 4	0.02 745 1	0.11 372 5	0.93 081 8	0.88 333 3	0.23 529 4	274 996	0.160332	335	335
3_6 0	#91 3a8 b	0.56 862 7	0.22 745 1	0.54 509 8	0.84 482 8	0.6 862 7	0.56 862 7	162 393	0.09468	304	300
3_6 0	#64 064 4	0.39 215 7	0.02 352 9	0.26 666 7	0.89 007 1	0.94 215 7	0.39 215 7	264 545	0.154238	320	320

3_6 0	#6f 2a5 7	0.43 529 4	0.16 470 6	0.34 117 6	0.89 130 4	0.62 162 2	0.43 529 4	123 447	0.071974	320	320
3_6 0	#75 096 1	0.45 882 4	0.03 529 4	0.38 039 2	0.86 419 8	0.92 307 7	0.45 882 4	249 752	0.145614	311	310
3_6 0	#9f 689 d	0.62 352 9	0.40 784 3	0.61 568 6	0.83 939 4	0.34 591 2	0.62 352 9	320 49	0.018686	302	300
3_6 0	#fcf cfc	0.98 823 5	0.98 823 5	0.98 823 5	0 0	0 0	0.98 823 5	149 214	0.086997	0	0
3_6 0	#55 113 3	0.33 333 3	0.06 666 7	0.2	0.91 666 7	0.8	0.33 333 3	222 418	0.129677	330	330
3_6 0	#7f 247 4	0.49 803 9	0.14 117 6	0.45 490 2	0.85 348	0.71 653 5	0.49 803 9	236 355	0.137803	307	305
3_7 0	#a3 2b8 1	0.63 921 6	0.16 862 7	0.50 588 2	0.88 055 6	0.73 619 6	0.63 921 6	980 547	0.143026	317	315
3_7 0	#9b 077 3	0.60 784 3	0.02 745 1	0.45 098	0.87 837 8	0.95 483 9	0.60 784 3	615 097	0.08972	316	315
3_7 0	#37 0a1 a	0.21 568 6	0.03 921 6	0.10 196 1	0.94 074 1	0.81 818 2	0.21 568 6	254 510	0.037124	338	335
3_7 0	#bf 56a 8	0.74 902 8	0.33 725 5	0.65 882 4	0.86 984 1	0.54 973 8	0.74 902	987 678	0.144067	313	310
3_7 0	#61 0c3 3	0.38 039 2	0.04 705 9	0.2	0.92 352 9	0.87 628 9	0.38 039 2	650 550	0.094892	332	330
3_7 0	#af 429 2	0.68 627 5	0.25 882 4	0.57 254 9	0.87 767 6	0.62 285 7	0.68 627 5	102 116 4	0.148951	315	315
3_7 0	#c8 7cb 9	0.78 431 4	0.48 627 5	0.72 549	0.86 622 8	0.38	0.78 431 4	581 436	0.084811	311	310
3_7 0	#88 266 5	0.53 333 3	0.14 902	0.39 607 8	0.89 285 7	0.72 058 8	0.53 333 3	787 506	0.114869	321	320

3_7 0	#7f 045 1	0.49 803 9	0.01 568 6	0.31 764 7	0.89 566 4	0.96 850 4	0.49 803 9	977 215	0.14254	322	320
3_8 0	#4f 0b3 0	0.30 980 4	0.04 313 7	0.18 823 5	0.90 931 4	0.86 075 9	0.30 980 4	215 387	0.125307	327	325
3_8 0	#87 136 a	0.52 941 2	0.07 451 6	0.41 568 6	0.87 5 9	0.85 925 9	0.52 941 2	134 204	0.078077	315	315
3_8 0	#90 297 8	0.56 470 6	0.16 078 4	0.47 058 8	0.87 216 8	0.71 527 8	0.56 470 6	205 800	0.11973	313	310
3_8 0	#71 094 e	0.44 313 7	0.03 529 4	0.30 588 2	0.88 942 3	0.92 035 4	0.44 313 7	249 897	0.145384	320	320
3_8 0	#90 417 1	0.56 470 6	0.25 490 2	0.44 313 7	0.89 873 4	0.54 861 1	0.56 470 6	189 600	0.110305	323	320
3_8 0	#b8 82b 3	0.72 156 9	0.50 980 4	0.70 196 1	0.84 876 5	0.29 347 8	0.72 156 9	115 371	0.06712	305	305
3_8 0	#7a 295 8	0.47 843 1	0.16 078 4	0.34 509 8	0.90 329 2	0.66 393 4	0.47 843 1	246 246	0.14326	325	325
3_8 0	#ac 5a9 d	0.67 451	0.35 294 1	0.61 568 6	0.86 382 1	0.47 674 4	0.67 451	159 396	0.092733	310	310
3_8 0	#a0 3d8 c	0.62 745 1	0.23 921 6	0.54 902	0.86 700 3	0.61 875 7	0.62 745 1	202 971	0.118084	312	310
3_8 7	#7b 2b4 b	0.48 235 3	0.16 862 7	0.29 411 8	0.93 333 3	0.65 040 7	0.48 235 3	533 931	0.101405	335	335
3_8 7	#a2 346 c	0.63 529 4	0.20 392 2	0.42 352 9	0.91 515 2	0.67 901 2	0.63 529 4	690 567	0.131154	329	325
3_8 7	#b7 0c7 8	0.71 764 7	0.04 705 9	0.47 058 8	0.89 473 7	0.93 442 6	0.71 764 7	736 280	0.139836	322	320
3_8 7	#cf 5fa 4	0.81 176 5	0.37 254 9	0.64 313 7	0.89 732 1	0.54 106 3	0.81 176 5	409 071	0.077692	323	320

3 7	#a8 608 2	0.65 882 4	0.37 647 1	0.50 980 4	0.92 129 6	0.42 857 1	0.65 882 4	289 275	0.05494	331	330
3 7	#d7 8cb 8	0.84 313 7	0.54 902 9	0.72 156 2	0.90 222 7	0.34 883 7	0.84 313 7	148 992	0.028297	324	320
3 7	#96 055 3	0.58 823 5	0.01 960 8	0.32 549	0.91 034 5	0.96 666 7	0.58 823 5	906 919	0.172244	327	325
3 7	#62 082 9	0.38 431 4	0.03 137 3	0.16 078 4	0.93 888 9	0.91 836 7	0.38 431 4	810 559	0.153943	337	335
3 7	#c3 3c8 f	0.76 470 6	0.23 529 4	0.56 078 4	0.89 753 1	0.69 230 8	0.76 470 6	739 718	0.140489	323	320
3 4	#a1 085 5	0.63 137 3	0.03 137 3	0.33 333 3	0.91 612 2	0.95 031 1	0.63 137 3	337 716	0.111445	329	325
3 4	#c5 5b8 e	0.77 254 9	0.35 686 3	0.55 686 3	0.91 981 1	0.53 807 1	0.77 254 9	337 977	0.111532	331	330
3 4	#c4 127 7	0.76 862 7	0.07 058 8	0.46 666 7	0.90 543 1	0.90 816 3	0.76 862 7	232 479	0.076717	325	325
3 4	#6f 0b2 f	0.43 529 4	0.04 313 7	0.18 431 4	0.94	0.90 090 1	0.43 529 4	239 010	0.078873	338	335
3 4	#b6 407 7	0.71 372 5	0.25 098	0.46 666 7	0.92 231 6	0.64 835 2	0.71 372 5	562 653	0.185674	332	330
3 4	#d5 439 1	0.83 529 4	0.26 274 5	0.56 862 7	0.91 095 9	0.68 544 6	0.83 529 4	303 207	0.100058	327	325
3 4	#d4 88a f	0.83 137 3	0.53 333 3	0.68 627 5	0.91 447 4	0.35 849 1	0.83 137 3	156 774	0.051735	329	325
3 4	#9c 315 f	0.61 176 5	0.19 215 7	0.37 254 9	0.92 834 9	0.68 589 7	0.61 176 5	546 498	0.180343	334	330
3 4	#d9 65a 2	0.85 098	0.39 607 8	0.63 529 4	0.91 235 6	0.53 456 2	0.85 098	314 013	0.103623	328	325

3 8	#63 143 a	0.38 823 5	0.07 843 1	0.22 745 1	0.91 983 1	0.79 798 5	0.38 823 5	804 728	0.089121	331	330
3 8	#be 53a 7	0.74 509 8	0.32 549 8	0.65 490 2	0.86 915 9	0.56 315 8	0.74 509 8	102 686 7	0.113722	312	310
3 8	#ac 4d9 1	0.67 451 1	0.30 196 1	0.56 862 7	0.88 070 2	0.55 232 6	0.67 451 6	109 947 6	0.121764	317	315
3 8	#90 477 1	0.56 470 6	0.27 843 1	0.44 313 7	0.90 411 7	0.50 694 4	0.56 470 6	698 186	0.077322	325	325
3 8	#c7 71b a	0.78 039 2	0.44 313 7	0.72 941 2	0.85 852 7	0.43 216 1	0.78 039 2	117 587 1	0.130224	309	305
3 8	#8a 1d6 0	0.54 117 6	0.11 372 5	0.37 647 1	0.89 755 4	0.78 985 5	0.54 117 6	135 058 9	0.149573	323	320
3 8	#d0 91c a	0.81 568 6	0.56 862 7	0.79 215 7	0.84 920 6	0.30 288 5	0.81 568 6	122 565 9	0.135738	305	305
3 8	#b3 74a 5	0.70 196 1	0.45 490 2	0.64 705 9	0.87 037 9	0.35 195 5	0.70 196 1	464 445	0.051436	313	310
3 8	#a5 2e8 2	0.64 705 9	0.18 039 2	0.50 980 4	0.88 235 3	0.72 121 2	0.64 705 9	118 378 1	0.1311	317	315
4 1	#f7f af8	0.96 862 7	0.98 039 2	0.97 254 9	0.38 888 9	0.01 2 9	0.98 039 2	304 26	0.00701	140	140
4 1	#5c 053 3	0.36 078 4	0.01 960 8	0.2 187 7	0.91 565 2	0.94 078 4	0.36 113	954 113	0.219821	328	325
4 1	#f9f efd	0.97 647 1	0.99 607 8	0.99 215 7	0.46 666 7	0.01 968 5	0.99 607 8	101 127	0.023299	168	165
4 1	#93 4b7 e	0.57 647 1	0.29 411 8	0.49 411 8	0.88 194 4	0.48 979 6	0.57 647 1	270 366	0.06229	317	315
4 1	#7e 316 5	0.49 411 8	0.19 215 7	0.39 607 8	0.88 744 6	0.61 111 1	0.49 411 8	879 150	0.20255	319	315

4_0 1	#75 0f5 0	0.45 882 4	0.05 882 4	0.31 372 5	0.89 379 1	0.87 179 5	0.45 882 4	695 198	0.160169	321	320
4_0 1	#3f 051 9	0.24 705 9	0.01 960 8	0.09 803 9	0.94 252 9	0.92 063 5	0.24 705 9	670 931	0.154578	339	335
4_0 1	#62 244 6	0.38 431 4	0.14 117 6	0.27 451	0.90 860 2	0.63 265 3	0.38 431 4	553 128	0.127437	327	325
4_0 1	#fef bfd	0.99 607 8	0.98 431 4	0.99 215 7	0.88 888 9	0.01 181 1	0.99 607 8	185 970	0.042846	319	315
4_0 1	#cc 9cc b	0.8	0.61 176 5	0.79 607 8	0.83 680 6	0.23 529 4	0.8	576 0	8.884390069 577885e_05	301	300
4_0 1	#40 061 b	0.25 098	0.02 352 9	0.10 588 2	0.93 965 5	0.90 625	0.25 098	986 705	0.015219	338	335
4_0 1	#b6 84b 4	0.71 372 5	0.51 764 7	0.70 588 2	0.84	0.27 472 5	0.71 372 5	526 02	0.000811	302	300
4_0 1	#6a 063 4	0.41 568 6	0.02 352 9	0.20 392 2	0.92 333 3	0.94 339 6	0.41 568 6	114 173 2	0.01761	332	330
4_0 1	#8b 035 5	0.54 509 8	0.01 176 5	0.33 333 3	0.89 951	0.97 841 7	0.54 509 8	112 969 2	0.017425	323	320
4_0 1	#b0 328 e	0.69 019 6	0.19 607 8	0.55 686 3	0.87 830 7	0.71 590 9	0.69 019 6	710 154	0.010954	316	315
4_0 1	#b0 5aa 0	0.69 019 6	0.35 294 1	0.62 745 1	0.86 434 1	0.48 863 6	0.69 019 6	227 409	0.003508	311	310
4_0 1	#7b 315 9	0.48 235 3	0.19 215 7	0.34 902	0.90 991	0.60 162 6	0.48 235 3	469 293	0.007239	327	325
4_0 1	#d9 d9d 9	0.85 098	0.85 098	0.85 098	0	0	0.85 098	591 167 13	0.911833	0	0
4_0 1	#a9 097 7	0.66 274 5	0.03 529 4	0.46 666 7	0.88 541 7	0.94 674 6	0.66 274 5	992 753	0.015313	318	315

4_1 0	#40 092 2	0.25 098	0.03 529 4	0.13 333 3	0.92 424 2	0.85 937 5	0.25 098	208 200	0.147572	332	330
4_1 0	#71 135 8	0.44 313 7	0.07 451	0.34 509 8	0.87 766	0.83 185 8	0.44 313 7	188 576	0.133662	315	315
4_1 0	#6a 2e5 1	0.41 568 6	0.18 039 2	0.31 764 7	0.90 277 8	0.56 603 8	0.41 568 6	128 958	0.091405	325	325
4_1 0	#7c 406 a	0.48 627 5	0.25 098	0.41 568 6	0.88 333 3	0.48 387 1	0.48 627 5	106 029	0.075153	318	315
4_1 0	#9e 5e9 8	0.61 960 8	0.36 862 7	0.59 607 8	0.84 895 8	0.40 506 3	0.61 960 8	110 253	0.078147	305	305
4_1 0	#80 296 e	0.50 196 1	0.16 078 4	0.43 137 3	0.86 781 6	0.67 968 8	0.50 196 1	155 091	0.109928	312	310
4_1 0	#91 418 5	0.56 862 7	0.25 490 2	0.52 156 9	0.85 833 3	0.55 172 4	0.56 862 7	140 673	0.099709	309	305
4_1 0	#5c 0b3 e	0.36 078 4	0.04 313 7	0.24 313 7	0.89 506 2	0.88 043 5	0.36 078 4	309 298	0.21923	322	320
4_1 0	#8d 538 2	0.55 294 1	0.32 549	0.50 980 4	0.86 494 3	0.41 134 8	0.55 294 1	637 62	0.045194	311	310
4_1 00	#a5 439 f	0.64 705 9	0.26 274 5	0.62 352 9	0.84 353 7	0.59 393 9	0.64 705 9	896 55	0.122952	303	300
4_1 00	#79 2f6 2	0.47 451	0.18 431 4	0.38 431 4	0.88 513 5	0.61 157	0.47 451	921 30	0.126346	318	315
4_1 00	#5a 0b3 3	0.35 294 1	0.04 313 7	0.2	0.91 561 2	0.87 777 8	0.35 294 1	884 40	0.121286	329	325
4_1 00	#b4 71b 8	0.70 588 2	0.44 313 7	0.72 156 9	0.82 394 4	0.38 587	0.72 156 9	311 01	0.042652	296	295
4_1 00	#93 308 6	0.57 647 1	0.18 823 5	0.52 549	0.85 521 9	0.67 346 9	0.57 647 1	153 873	0.21102	307	305

4_1 00	#8d 548 3	0.55 294 1	0.32 941 2	0.51 372 5	0.86 257 3	0.40 425 5	0.55 294 1	441 90	0.060602	310	310
4_1 00	#32 091 b	0.19 607 8	0.03 529 4	0.10 588 2	0.92 682 9	0.82	0.19 607 8	421 40	0.05779	333	330
4_1 00	#71 0a4 e	0.44 313 7	0.03 921 6	0.30 588 2	0.88 996 8	0.91 150 4	0.44 313 7	956 08	0.131116	320	320
4_1 00	#87 0c7 0	0.52 941 2	0.04 705 9	0.43 921 6	0.86 449 9	0.91 111 1	0.52 941 2	920 51	0.126238	311	310
4_1 02	#c5 84b 2	0.77 254 9	0.51 764 7	0.69 803 9	0.88 205 1	0.32 994 9	0.77 254 9	398 061	0.038052	317	315
4_1 02	#70 073 6	0.43 921 6	0.02 745 1	0.21 176 5	0.92 539 7	0.93 75	0.43 921 6	146 040 5	0.139604	333	330
4_1 02	#a6 1c7 5	0.65 098	0.10 980 4	0.45 882 4	0.89 251 2	0.83 132 5	0.65 098	157 133 5	0.150208	321	320
4_1 02	#86 325 b	0.52 549	0.19 607 8	0.35 686 3	0.91 865 1	0.62 686 6	0.52 549	110 052 6	0.105202	330	330
4_1 02	#8c 065 6	0.54 902	0.02 352 9	0.33 725 5	0.90 049 8	0.95 714 3	0.54 902	173 860 7	0.166198	324	320
4_1 02	#c0 5fa 1	0.75 294 1	0.37 254 9	0.63 137 3	0.88 659 8	0.50 520 8	0.75 294 1	896 976	0.085744	319	315
4_1 02	#b0 428 8	0.69 019 6	0.25 882 4	0.53 333 3	0.89 393 9	0.62 5	0.69 019 6	169 851 0	0.162365	321	320
4_1 02	#fcf cfc	0.98 823 5	0.98 823 5	0.98 823 5	0	0	0.98 823 5	738 387	0.070584	0	0
4_1 02	#4c 092 1	0.29 803 9	0.03 529 4	0.12 941 2	0.94 029 9	0.88 157 9	0.29 803 9	858 252	0.082043	338	335
4_1 2	#89 196 0	0.53 725 5	0.09 803 9	0.37 647 1	0.89 434 5	0.81 751 8	0.53 725 5	317 366	0.157282	321	320

4 2	#9f 6f9 0	0.62 352 9	0.43 529 4	0.56 470 6	0.88 541 7	0.30 188 7	0.62 352 9	377 64	0.018715	318	315
4 2	#80 346 1	0.50 196 1	0.20 392 2	0.38 039 2	0.90 131 6	0.59 375 6	0.50 196 1	217 821	0.107949	324	320
4 2	#fbf cfc	0.98 431 4	0.98 823 5	0.98 823 5	0.5	0.00 396 8	0.98 823 5	183 189	0.090786	180	180
4 2	#97 357 6	0.59 215 7	0.20 784 3	0.46 274 5	0.88 945 6	0.64 900 7	0.59 215 7	194 268	0.096276	320	320
4 2	#90 4e7 5	0.56 470 6	0.30 588 2	0.45 882 4	0.90 151 5	0.45 833 3	0.56 470 6	840 09	0.041634	324	320
4 2	#6a 204 1	0.41 568 6	0.12 549 5	0.25 490 2	0.92 567 6	0.69 811 3	0.41 568 6	175 341	0.086896	333	330
4 2	#51 072 3	0.31 764 7	0.02 745 1	0.13 725 5	0.93 693 7	0.91 358 7	0.31 764 7	402 573	0.199509	337	335
4 2	#79 034 8	0.47 451 5	0.01 176 5	0.28 235 3	0.90 254 2	0.97 520 7	0.47 451 5	405 489	0.200954	324	320
4 1	#a6 7aa 3	0.65 098 1	0.47 843 1	0.63 921 6	0.84 469 7	0.26 506 7	0.65 098 1	805 44	0.001215	304	300
4 1	#d1 d1d 1	0.81 960 8	0.81 960 8	0.81 960 8	0	0	0.81 960 8	613 818 48	0.926065	0	0
4 1	#6d 1f5 4	0.42 745 1	0.12 156 9	0.32 941 2	0.88 675 2	0.71 559 6	0.42 745 1	737 543	0.011127	319	315
4 1	#5d 193 d	0.36 470 6	0.09 803 9	0.23 921 6	0.91 176 5	0.73 118 3	0.36 470 6	823 593	0.012426	328	325
4 1	#79 376 7	0.47 451 6	0.21 568 6	0.40 392 2	0.87 878 8	0.54 545 5	0.47 451 6	110 566 2	0.016681	316	315
4 1	#8b 497 f	0.54 509 8	0.28 627 5	0.49 803 9	0.86 363 6	0.47 482 8	0.54 509 8	790 851	0.011932	310	310

4 1	#9a 609 2	0.60 392 2	0.37 647 1	0.57 254 9	0.85 632 2	0.37 662 3	0.60 392 2	356 913	0.005385	308	305
4 1	#46 082 5	0.27 451	0.03 137 3	0.14 509 8	0.92 204 3	0.88 571 4	0.27 451	768 083	0.011588	331	330
4 1	#fbf bfb	0.98 431 4	0.98 431 4	0.98 431 4	0 0	0 0	0.98 431 4	237 390	0.003581	0	0
4 1	#98 418 c	0.59 607 8	0.25 490 2	0.54 902	0.85 632 2	0.57 236 8	0.59 607 8	565 998	0.165041	308	305
4 1	#79 1d5 d	0.47 451	0.11 372 5	0.36 470 6	0.88 405 8	0.76 033 1	0.47 451	586 773	0.171099	318	315
4 1	#3a 071 e	0.22 745 1	0.02 745 1	0.11 764 7	0.92 483 7	0.87 931	0.22 745 1	305 669	0.089131	332	330
4 1	#8b 2f7 6	0.54 509 8	0.18 431 4	0.46 274 5	0.87 137 7	0.66 187 1	0.54 509 8	667 103	0.194523	313	310
4 1	#a9 5aa 6	0.66 274 5	0.35 294 1	0.65 098	0.83 966 2	0.46 745 6	0.66 274 5	314 739	0.091776	302	300
4 1	#62 0d3 c	0.38 431 4	0.05 098	0.23 529 4	0.90 784 3	0.86 734 7	0.38 431 4	456 992	0.133256	326	325
4 1	#bd 67b 8	0.74 117 6	0.40 392 2	0.72 156 9	0.84 302 3	0.45 502 6	0.74 117 6	153 297	0.0447	303	300
4 1	#ad 429 f	0.67 843 1	0.25 882 4	0.62 352 9	0.85 514	0.61 849 7	0.67 843 1	347 802	0.101417	307	305
4 1	#b3 7da c	0.70 196 1	0.49 019 6	0.67 451	0.85 493 8	0.30 167 6	0.70 196 1	310 59	0.009057	307	305
4 0	#a2 4b9 5	0.63 529 4	0.29 411 8	0.58 431 4	0.85 823 8	0.53 703 7	0.63 529 4	313 920	0.109697	308	305
4 0	#a8 64a 4	0.65 882 4	0.39 215 7	0.64 313 7	0.84 313 7	0.40 476 2	0.65 882 4	300 465	0.104995	303	300

4_3 0	#b2 76b 2	0.69 803 9	0.46 274 5	0.69 803 9	0.83 333 3	0.33 707 9	0.69 803 9	215 952	0.075463	300	300
4_3 0	#8f 397 a	0.56 078 4	0.22 352 9	0.47 843 1	0.87 403 1	0.60 139 9	0.56 078 4	539 892	0.188661	314	310
4_3 0	#69 284 c	0.41 176 5	0.15 686 3	0.29 803 9	0.90 769 2	0.61 904 8	0.41 176 5	277 326	0.09691	326	325
4_3 0	#6c 074 2	0.42 352 9	0.02 745 1	0.25 882 4	0.90 264	0.93 518 5	0.42 352 9	366 871	0.1282	324	320
4_3 0	#83 1f6 3	0.51 372 5	0.12 156 9	0.38 823 5	0.88 666 7	0.76 335 9	0.51 372 5	490 251	0.171315	319	315
4_3 0	#b9 91b c	0.72 549	0.56 862 7	0.73 725 5	0.82 170 5	0.22 872 3	0.73 725 5	130 293	0.04553	295	295
4_3 0	#4b 0b2 6	0.29 411 8	0.04 313 7	0.14 902	0.92 968 8	0.85 333 3	0.29 411 8	226 730	0.079229	334	330
4_0 4	#92 3a7 c	0.57 254 9	0.22 745 1	0.48 627 5	0.87 5	0.60 274	0.57 254 9	190 545	0.082035	315	315
4_0 4	#70 1f5 3	0.43 921 6	0.12 156 9	0.32 549	0.89 300 4	0.72 321 4	0.43 921 6	531 538	0.228841	321	320
4_0 4	#9d 4e8 d	0.61 568 6	0.30 588 2	0.55 294 1	0.86 708 9	0.50 318 5	0.61 568 6	772 80	0.033271	312	310
4_0 4	#64 0a3 c	0.39 215 7	0.03 921 6	0.23 529 4	0.90 740 7	0.9 215 7	0.39 215 7	532 189	0.229122	326	325
4_0 4	#42 071 e	0.25 882 4	0.02 745 1	0.11 764 7	0.93 502 8	0.89 393 9	0.25 882 4	371 522	0.15995	336	335
4_0 4	#83 296 7	0.51 372 5	0.16 078 4	0.40 392 2	0.88 518 5	0.68 702 3	0.51 372 5	300 393	0.129327	318	315
4_0 4	#87 5a8 0	0.52 941 2	0.35 294 1	0.50 196 1	0.85 925 9	0.33 333 3	0.52 941 2	814 92	0.035084	309	305

4 4	#a1 769 d	0.63 137 3	0.46 274 5	0.61 568 6	0.84 883 7	0.26 708 1	0.63 137 3	177 21	0.007629	305	305
4 4	#77 446 9	0.46 666 7	0.26 666 7	0.41 176 5	0.87 908 5	0.42 857 1	0.46 666 7	220 056	0.09474	316	315
4 0	#b7 73a 2	0.71 764 7	0.45 098 7	0.63 529 4	0.88 480 4	0.37 158 5	0.71 764 7	193 86	0.013583	318	315
4 0	#95 137 b	0.58 431 4	0.07 451 4	0.48 235 3	0.86 666 7	0.87 248 3	0.58 431 4	116 373	0.081537	312	310
4 0	#2f 081 6	0.18 431 4	0.03 137 3	0.08 627 5	0.94 017 1	0.82 978 7	0.18 431 4	111 375	0.078035	338	335
4 0	#54 062 c	0.32 941 2	0.02 352 9	0.17 254 9	0.91 880 3	0.92 857 1	0.32 941 2	201 330	0.141063	330	330
4 0	#81 2a6 b	0.50 588 2	0.16 470 6	0.41 960 8	0.87 547 9	0.67 441 9	0.50 588 2	202 260	0.141714	315	315
4 0	#7b 095 d	0.48 235 3	0.03 529 4	0.36 470 6	0.87 719 3	0.92 682 9	0.48 235 3	304 586	0.21341	315	315
4 0	#98 368 7	0.59 607 8	0.21 176 5	0.52 941 2	0.86 224 5	0.64 473 7	0.59 607 8	108 972	0.076352	310	310
4 0	#b1 3d9 c	0.69 411 8	0.23 921 6	0.61 176 5	0.86 350 6	0.65 536 7	0.69 411 8	419 55	0.029396	310	310
4 0	#69 064 4	0.41 176 5	0.02 352 9	0.26 666 7	0.89 562 3	0.94 285 7	0.41 176 5	321 000	0.22491	322	320
4 2	#54 032 9	0.32 941 2	0.01 176 5	0.16 078 4	0.92 181 1	0.96 428 6	0.32 941 2	573 54	0.066003	331	330
4 2	#68 0c4 6	0.40 784 3	0.04 705 9	0.27 451 8	0.89 492 8	0.88 461 5	0.40 784 3	104 040	0.119728	322	320
4 2	#bf 80b 7	0.74 902 7	0.50 196 1	0.71 764 7	0.85 449 7	0.32 984 3	0.74 902 7	820 98	0.094478	307	305

4 2	#81 196 3	0.50 588 2	0.09 803 9	0.38 823 5	0.88 141	0.80 620 2	0.50 588 2	121 456	0.139771	317	315
4 2	#38 081 8	0.21 960 8	0.03 137 3	0.09 411 8	0.94 444 4	0.85 714 3	0.21 960 8	220 09	0.025328	340	340
4 2	#58 213 9	0.34 509 8	0.12 941 2	0.22 352 9	0.92 727 3	0.62 5	0.34 509 8	243 63	0.028037	333	330
4 2	#8c 3c7 9	0.54 902	0.23 529 4	0.47 451	0.87 291 7	0.57 142 9	0.54 902	195 528	0.225012	314	310
4 2	#a6 559 7	0.65 098	0.33 333 3	0.59 215 7	0.86 419 8	0.48 795 2	0.65 098	156 654	0.180276	311	310
4 2	#6c 2a5 9	0.42 352 9	0.16 470 6	0.34 902	0.88 131 3	0.61 111 1	0.42 352 9	105 465	0.121368	317	315
4 2	#33 061 8	0.2	0.02 352 9	0.09 411 8	0.93 333 3	0.88 235 3	0.2	310 578	0.114644	335	335
4 2	#8a 498 3	0.54 117 6	0.28 627 5	0.51 372 5	0.85 128 2	0.47 101 4	0.54 117 6	414 792	0.153112	306	305
4 2	#98 5f9 8	0.59 607 8	0.37 254 9	0.59 607 8	0.83 333 3	0.37 5	0.59 607 8	372 711	0.137579	300	300
4 2	#a6 7ca e	0.65 098	0.48 627 5	0.68 235 3	0.80 666 7	0.28 735 6	0.68 235 3	270 345	0.099792	290	290
4 2	#fcf cfc	0.98 823 5	0.98 823 5	0.98 823 5	0	0	0.98 823 5	173 472	0.064034	0	0
4 2	#72 195 4	0.44 705 9	0.09 803 9	0.32 941 2	0.88 951 3	0.78 070 2	0.44 705 9	213 655	0.078866	320	320
4 2	#53 0b3 1	0.32 549	0.04 313 7	0.19 215 7	0.91 203 7	0.86 747	0.32 549	354 035	0.130685	328	325
4 2	#7c 376 9	0.48 627 5	0.21 568 6	0.41 176 5	0.87 922 7	0.55 645 2	0.48 627 5	374 433	0.138214	316	315

4 2	#62 2a4 b	0.38 431 4	0.16 470 6	0.29 411 8	0.90 178 6	0.57 142 9	0.38 431 4	225 054	0.083074	324	320
4 5	#a6 357 9	0.65 098	0.20 784 3	0.47 451	0.89 970 5	0.68 072 3	0.65 098	660 962	0.010843	323	320
4 5	#eb ebe b	0.92 156 9	0.92 156 9	0.92 156 9	0	0	0.92 156 9	547 343 49	0.897871	0	0
4 5	#43 091 b	0.26 274 5	0.03 529 4	0.10 588 2	0.94 827 6	0.86 567 2	0.26 274 5	595 108	0.009762	341	340
4 5	#8b 3d6 a	0.54 509 8	0.23 921 6	0.41 568 6	0.90 384 6	0.56 115 1	0.54 509 8	909 642	0.014922	325	325
4 5	#6a 0b3 1	0.41 568 6	0.04 313 7	0.19 215 7	0.93 333 3	0.89 622 6	0.41 568 6	757 155	0.01242	335	335
4 5	#b6 7ca 8	0.71 372 5	0.48 627 5	0.65 882 4	0.87 356 3	0.31 868 1	0.71 372 5	589 434	0.009669	314	310
4 5	#92 155 5	0.57 254 9	0.08 235 3	0.33 333 3	0.91 466 7	0.85 616 4	0.57 254 9	479 462	0.007865	329	325
4 5	#b4 559 5	0.70 588 2	0.33 333 3	0.58 431 4	0.88 771 9	0.52 777 8	0.70 588 2	704 208	0.011552	319	315
4 5	#9d 558 4	0.61 568 6	0.33 333 3	0.51 764 7	0.89 120 4	0.45 859 9	0.61 568 6	823 833	0.013514	320	320
4 5	#76 2b4 f	0.46 274 5	0.16 862 7	0.30 980 4	0.92	0.63 559 3	0.46 274 5	706 023	0.011582	331	330
4 6	#b2 67b 0	0.69 803 9	0.40 392 2	0.69 019 6	0.83 777 8	0.42 134 8	0.69 803 9	134 280 6	0.020511	301	300
4 6	#53 0c2 f	0.32 549	0.04 705 9	0.18 431 4	0.91 784	0.85 542 2	0.32 549	135 313 1	0.020669	330	330
4 6	#73 1a5 1	0.45 098	0.10 196 1	0.31 764 7	0.89 700 4	0.77 391 3	0.45 098	183 896 0	0.02809	322	320

4 <sub>6</sub>	#7f	0.49	0.22	0.40	0.88	0.54	0.49	135	0.020698	320	320
	3a6	803	745	784	888	330	803	502			
	8	9	1	3	9	7	9	2			
4 <sub>6</sub>	#be	0.74	0.54	0.74	0.83	0.27	0.74	106	0.016192	298	295
	8ab	509	117	902	018	748	902	007			
	f	8	6		9	7		4			
4 <sub>6</sub>	#f0f	0.94	0.94	0.94	0	0	0.94	536	0.820026	0	0
	0f0	117	117	117			117	849			
		6	6	6			6	49			
4 <sub>6</sub>	#91	0.56	0.17	0.48	0.86	0.69	0.56	124	0.018995	313	310
	2c7	862	254	235	963	655	862	353			
	b	7	9	3	7	2	7	2			
4 <sub>6</sub>	#93	0.57	0.30	0.51	0.86	0.46	0.57	118	0.018055	313	310
	4e8	647	588	764	956	938	647	203			
	4	1	2	7	5	8	1	0			
4 <sub>6</sub>	#a6	0.65	0.43	0.62	0.85	0.33	0.65	760	0.011611	307	305
	6f9f	098	529	352	454	132	098	128			
			4	9	5	5					
4 <sub>6</sub>	#a3	0.63	0.30	0.6	0.85	0.52	0.63	164	0.025154	306	305
	4d9	921	196		271	760	921	675			
	9	6	1		3	7	6	7			
4 <sub>8</sub>	#a4	0.64	0.4	0.64	0.83	0.38	0.64	138	0.144184	299	295
	66a	313		705	068	181	705	540			
	5	7		9	8	8	9				
4 <sub>8</sub>	#a9	0.66	0.47	0.67	0.82	0.29	0.67	973	0.101301	296	295
	79a	274	451	451	352	651	451	35			
	c	5			9	2					
4 <sub>8</sub>	#69	0.41	0.12	0.30	0.89	0.70	0.41	124	0.130078	322	320
	1f4	176	156	196	639	476	176	986			
	d	5	9	1	6	2	5				
4 <sub>8</sub>	#7e	0.49	0.21	0.40	0.88	0.57	0.49	143	0.149442	318	315
	366	411	176	784	425	142	411	592			
	8	8	5	3	9	9	8				
4 <sub>8</sub>	#8f	0.56	0.26	0.50	0.86	0.52	0.56	139	0.14513	311	310
	448	078	666	588	444	447	078	449			
	1	4	7	2	4	6	4				
4 <sub>8</sub>	#4a	0.29	0.05	0.17	0.91	0.79	0.29	826	0.086044	329	325
	0f2	019	882	647	525	729	019	76			
	d	6	4	1	4	7	6				
4 <sub>8</sub>	#93	0.57	0.38	0.57	0.83	0.32	0.57	875	0.09115	301	300
	639	647	823	254	680	653	647	82			
	2	1	5	9	6	1	1				

4_8 0	#b5 90b a	0.70 980 4	0.56 470 6	0.72 941 2	0.81 349 2	0.22 580 6	0.72 941 2	394 65	0.041073	292	290
4_8 0	#9e 519 6	0.61 960 8	0.31 764 7	0.58 823 5	0.85 064 9	0.48 734 2	0.61 960 8	107 229	0.111598	306	305
4_8 0	#73 106 2	0.45 098 5	0.06 274 5	0.38 431 4	0.86 195 3	0.86 087 3	0.45 098 3	203 785	0.120855	310	310
4_8 0	#5b 0a4 0	0.35 686 3	0.03 921 6	0.25 098 9	0.88 888 9	0.89 011 3	0.35 686 3	232 215	0.137715	320	320
4_8 0	#ab 85b 3	0.67 058 8	0.52 156 9	0.70 196 1	0.80 434 8	0.25 698 3	0.70 196 1	416 40	0.024695	289	285
4_8 0	#35 061 e	0.20 784 3	0.02 352 9	0.11 764 7	0.91 489 4	0.88 679 2	0.20 784 3	217 450	0.128959	329	325
4_8 0	#86 418 9	0.52 549 2	0.25 490 5	0.53 725 9	0.82 638 9	0.52 554 7	0.53 725 5	166 656	0.098835	297	295
4_8 0	#88 207 e	0.53 333 3	0.12 549 8	0.49 411 8	0.84 935 9	0.76 470 6	0.53 333 3	187 212	0.111026	305	305
4_8 0	#75 2f6 e	0.45 882 4	0.18 431 4	0.43 137 3	0.85	0.59 829 1	0.45 882 4	109 731	0.065076	306	305
4_8 0	#96 379 5	0.58 823 5	0.21 568 6	0.58 431 4	0.83 508 8	0.63 333 3	0.58 823 5	248 940	0.147634	300	300
4_8 0	#9b 52a 4	0.60 784 3	0.32 156 9	0.64 313 7	0.81 504 1	0.5	0.64 313 7	278 571	0.165206	293	290
4_8 4	#50 0b2 d	0.31 372 5	0.04 313 7	0.17 647 1	0.91 787 4	0.86 25	0.31 372 5	332 004	0.104854	330	330
4_8 4	#75 0d4 e	0.45 882 4	0.05 098 4	0.30 588 2	0.89 583 3	0.88 888 9	0.45 882 4	326 110	0.102993	322	320
4_8 4	#64 2b4 8	0.39 215 7	0.16 862 7	0.28 235 3	0.91 520 5	0.57	0.39 215 7	270 834	0.085535	329	325

4_8 4	#b7 80b 9	0.71 764 7	0.50 196 1	0.72 549	0.82 748 5	0.30 810 8	0.72 549	432 369	0.136552	297	295
4_8 4	#a4 529 c	0.64 313 7	0.32 156 9	0.61 176 5	0.84 959 3	0.5 313 7	0.64 265	491 265	0.155152	305	305
4_8 4	#7e 326 3	0.49 411 8	0.19 607 8	0.38 823 5	0.89 254 4	0.60 317 5	0.49 411 8	421 833	0.133224	321	320
4_8 4	#94 368 0	0.58 039 2	0.21 176 5	0.50 196 1	0.86 879 4	0.63 513 5	0.58 039 2	373 861	0.118074	312	310
4_8 4	#88 527 9	0.53 333 3	0.32 156 9	0.47 451	0.87 963	0.39 705 9	0.53 333 3	260 406	0.082242	316	315
4_8 4	#a1 6e9 e	0.63 137 3	0.43 137 3	0.61 960 8	0.84 313 7	0.31 677 3	0.63 137 3	257 655	0.081373	303	300
4_9 5	#9a 396 8	0.60 392 2	0.22 352 9	0.40 784 3	0.91 924 4	0.62 987	0.60 392 2	435 03	0.131813	330	330
4_9 5	#5c 203 3	0.36 078 4	0.12 549	0.2	0.94 722 2	0.65 217 4	0.36 078 4	298 15	0.090339	341	340
4_9 5	#87 124 d	0.52 941 2	0.07 058 8	0.30 196 1	0.91 595 4	0.86 666 7	0.52 941 2	402 16	0.121854	329	325
4_9 5	#b4 419 2	0.70 588 2	0.25 490 2	0.57 254 9	0.88 260 9	0.63 888 9	0.70 588 2	514 68	0.155947	317	315
4_9 5	#a0 728 b	0.62 745 1	0.44 705 9	0.54 509 8	0.90 942	0.28 75	0.62 745 1	940 2	0.028488	327	325
4_9 5	#c1 53a c	0.75 686 3	0.32 549	0.67 451	0.86 515 2	0.56 994 8	0.75 686 3	531 09	0.160919	311	310
4_9 5	#cb 77b 8	0.79 607 8	0.46 666 7	0.72 156 9	0.87 103 2	0.41 379 3	0.79 607 8	379 38	0.114951	313	310
4_9 5	#df 99d 1	0.87 451	0.6	0.81 960 8	0.86 666 7	0.31 390 1	0.87 451	324 18	0.098226	312	310

4_9	#a8	0.65	0.09	0.48	0.88	0.85	0.65	321	0.097462	318	315
5	187	882	411	627	425	714	882	66			
	c	4	8	5	9	3	4				

APPENDIX F

Principal Components 1-5 of F2 SNP data

Sample	PC1	PC2	PC3	PC4	PC5
1_05	26.52159	13.95728	-21.8373	17.67139	-7.09442
1_23	31.93996	11.32426	3.875369	6.667858	8.851681
1_31	23.41962	-12.9706	-20.1947	9.605237	-9.65386
1_39	11.74819	-0.45217	-17.1463	-5.0736	-4.05482
1_47	37.86874	9.761823	-18.4643	21.95081	24.01395
1_48	11.79053	-3.49725	9.542281	1.333671	5.478425
1_51	25.48275	-1.19281	-24.4637	11.88394	25.89657
1_60	18.30594	-41.3392	7.917353	35.54137	5.53999
1_61	30.314	-39.2991	36.87186	-41.9781	10.37237
1_67	32.69949	-4.60651	39.09838	-1.09544	-28.0131
1_74	43.50898	26.35231	33.35805	23.98899	11.35761
1_76	37.81013	-1.74628	-6.26105	-14.6874	-38.2615
2_100	38.02045	33.31771	-22.0984	14.21213	6.788263
2_108	-34.1868	26.55171	28.60681	-1.49447	1.812268
2_24	-29.647	-14.2251	4.539452	15.29949	14.4857
2_34	-16.5527	1.507803	14.66373	8.186867	-16.7433
2_43	-15.1105	12.46154	2.061633	-6.4274	-0.58966
2_46	-44.494	-23.8603	-19.8044	28.40954	8.427694
2_70	-27.8848	26.3113	-2.63673	18.55571	22.38352
2_98	35.77202	-35.0929	-8.77265	-6.282	-37.4022
3_10	-40.4903	-37.54	-3.28693	44.34805	-13.0971
3_102	-22.2611	4.254743	-9.50936	21.347	0.850907
3_33	-39.0386	-2.62457	1.749679	5.932697	-14.6488
4_01	-23.497	-21.8459	-8.46115	-26.3274	-25.0704
4_21	-13.9568	1.627227	2.600731	-17.2966	-15.8185
4_55	-41.5341	-23.9624	34.33935	3.397667	-5.9499
4_66	-25.8085	10.31101	1.839539	-0.80341	-9.22664
1_04	25.1991	-10.5975	-22.1981	6.906162	3.516961
1_10	48.01667	48.16354	10.25757	-3.09535	-40.7806
1_11	34.79928	30.04007	5.961137	-1.01228	-22.3724
1_18	19.13963	-22.8475	-27.7416	6.119555	-19.9117
1_19	15.56517	-25.2913	-31.0974	-24.2551	33.67555
1_24	37.26751	16.36439	31.42762	-6.87104	-0.45096

1_25	40.87066	32.84449	-13.6448	0.23805	-12.384
1_26	20.4157	2.469591	-36.2382	28.35285	-7.77719
1_32	-13.186	16.42312	1.382216	13.76561	1.009488
1_33	35.06227	32.3634	-15.9913	23.33579	-11.8715
1_37	28.92967	0.942623	8.350935	16.85943	-12.1272
1_38	9.017364	16.78969	-2.9115	12.8561	-1.76669
1_41	32.77256	22.66811	-15.9323	7.321053	30.5355
1_44	39.57362	13.69472	20.00845	-23.0083	20.02293
1_53	31.2999	-10.7944	45.52261	39.87045	-1.1072
1_54	22.40829	-1.9449	-17.744	18.49971	-1.36786
1_57	23.70981	-1.30363	-3.92733	2.360355	0.602151
1_59	30.93236	3.529586	-18.0884	11.97154	15.01982
1_62	20.59298	-46.6812	4.146813	-6.56618	5.47988
1_71a	23.99157	4.967504	-1.31225	7.155888	-8.64456
1_72	15.00413	0.256	-7.62494	-4.14959	11.97955
1_78	24.54743	-35.704	-20.2788	-13.2898	6.11197
1_79	28.97819	2.25712	43.74328	0.79609	63.7943
1_81	5.888822	-20.1509	-19.8739	-18.2775	-1.09006
1_82	44.87251	-3.14562	19.05284	-15.5076	-46.5238
1_85	9.939662	-21.8561	8.482268	-36.1039	6.584693
1_87	22.81113	-16.2555	-36.2481	-44.6547	-5.58373
1_88	6.780304	-16.0478	-32.7802	-19.3746	-8.68333
1_89	25.57104	-22.861	-6.44634	0.309342	-10.6458
1_91	36.13891	8.729287	38.72535	13.57875	-17.2979
1_92	20.46456	-7.4015	-0.11716	10.22164	-20.2503
2_02	-26.4616	0.936913	28.25105	-42.8575	-13.7384
2_03	-31.934	-6.66013	-35.9543	-1.30948	9.62374
2_04	17.47151	-41.6334	-18.5178	-16.6338	35.505
2_09	-26.7238	29.79783	-25.3182	-41.9746	-8.33424
2_10	-20.8997	23.05162	2.57777	1.59587	1.593141
2_127	9.107756	-44.2826	18.60346	36.32873	-33.1522
2_14	-23.1602	17.84678	-34.3973	-1.42028	7.421231
2_20	-24.2287	19.5863	-35.1174	7.713396	2.620927
2_21	-34.2269	-13.5268	-3.06115	18.14994	15.84422
2_22	-21.723	-14.9011	31.49481	-0.35837	-16.3827
2_25	-31.8403	28.96275	4.612363	9.201807	28.68819
2_29	-35.0138	-3.76039	36.44926	2.021079	20.34519
2_31	17.32699	-30.5915	1.275476	18.64099	-6.78248
2_38	-14.9017	-11.5274	-9.50851	13.91918	-14.4117
2_39	-16.7302	21.80612	5.529112	-12.2603	-5.10362
2_40	29.31645	-41.2553	36.28697	-41.5756	9.416973
2_41	1.759648	4.954436	6.239007	-0.42447	2.832964

2_52	30.20416	-3.26151	-12.3375	-0.36114	-4.88434
2_63	-15.931	0.645116	-0.0697	3.429169	2.049823
2_64	-41.8597	-11.1621	-10.3594	1.337469	-7.04557
2_69	-2.49114	38.90178	30.19544	-12.1477	16.42814
2_80	34.9485	6.766307	-10.846	-4.91867	32.77062
2_82	37.21419	31.25354	-17.8879	2.897524	3.95623
2_94	26.43452	-6.84632	-26.5565	-7.511	-0.16747
3_01	-8.73802	17.33057	-11.4342	-30.3174	9.934135
3_100	-26.4049	-7.67819	-1.4396	3.670054	-13.8716
3_15	-34.0618	-12.6975	-14.0355	29.76183	-15.0893
3_20	-21.4566	22.87747	-7.68743	-18.517	14.78651
3_21	24.26934	-32.01	6.005498	-15.4618	37.61327
3_30	23.21188	4.184918	37.58401	1.016714	56.99601
3_40	-31.3109	-3.31458	18.78522	20.51703	7.764186
3_50	-32.2131	3.469501	-2.3916	-2.70153	-6.26545
3_54	-37.4402	10.6008	-17.464	-37.5904	-4.33775
3_60	-29.4102	25.82025	14.06863	15.86853	-2.33599
3_80	-16.8206	3.639671	-8.35022	14.65725	6.687128
3_87	-27.2739	8.445336	-3.68122	-9.09772	8.248613
3_94	-39.6666	-29.4541	7.362288	12.41523	0.561639
3_98	-31.2967	7.375821	-3.25756	5.486492	9.637193
4_04	-40.1928	-21.8406	6.369258	-29.2294	8.960829
4_10	-32.0441	32.47625	-11.1042	-12.2046	9.66789
4_100	-32.2673	-0.09936	43.23747	20.41224	8.05956
4_102	-29.1445	-24.4046	-6.91217	-22.2753	-2.21319
4_12	-38.7395	-7.32963	14.76729	-19.1646	-8.06185
4_126	-23.5621	21.1027	-35.1541	-8.75334	-6.63748
4_30	-47.2011	-13.9379	-2.06358	26.00803	3.308421
4_40	-25.084	18.61593	4.649173	-16.9146	17.77401
4_52	-32.8743	23.73197	-3.87003	-5.31018	-24.6978
4_80	9.075586	26.99679	34.46464	-3.16264	-24.9108
4_84	-30.2891	0.069554	7.213798	18.01996	-8.43248
4_95	-22.838	27.82411	27.7635	-39.834	-30.5703