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733 Third Avenue, 19th Floor, Suite 1950, New York, NY 10017
Telephone: +1 (212) 642-1700 email: wknox@inta.org

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SHOULD WE WORRY ABOUT COLOR DEPLETION? AN EMPIRICAL STUDY OF USPTO SINGLE-COLOR TRADEMARK REGISTRATIONS[*]

By Dr. Xiaoren Wang[**]

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[**] Dr. Xiaoren Wang (xwang002@dundee.ac.uk), Lecturer/Assistant Professor in IP Law, University of Dundee (UK), Research Fellows, CREATe Centre, University of Glasgow (UK), Global Fellows, New York University, Visiting Scholar, Oxford IP Research Centre, University of Oxford (UK), JSD 2019, University of Illinois (US). The research is partially funded by the UK Creative Industries Policy and Evidence Centre (PEC) under Arts and Humanities Research Council (AHRC) grant AH/S001298/1. I am thankful to Barton Beebe, Paul Heald, Dev Gangjee, Michael Birnhack, Colin Reid, Emanuela Lecchi, and Angela Daly for their comments on the early versions of this article.

ABSTRACT

Trademark law across the United States ("U.S."), European Union ("EU"), and United Kingdom ("UK") allows companies to register single colors as trademarks, thereby preventing competitors from registering and using the same or confusingly similar colors in related markets.[1] Allowing companies the exclusive right to use and register single-color trademarks, however, may ultimately lead to color depletion: when more colors are registered and protectable as trademarks, fewer colors are available for new entrants. With fewer color options left, color depletion can create market entry barriers and impose anticompetitive costs on new entrants. Psychological and marketing research suggests that color depletion and concentration may exist in business-preferred colors, but scholars debate whether color depletion is severe in practice. Unfortunately, there has been no quantitative empirical research assessing the actual severity of color concentration and depletion—until now.

This article explores the findings of the first quantitative investigation into the extent of color concentration and depletion. The color study uses a software program written in the Python language to code and analyze 854 single-color trademark applications and registrations across all 45 international classes of goods and services recorded in the United States Patent and Trademark Office ("USPTO"). The study reveals that trademark filings are most concentrated in the red hue segment and in color areas with high brightness and high saturation. The results of this study lead us to estimate that there may be substantial depletion in certain classes; for example, according to our methodology: 41% of the color space has been claimed in Class 9 (electronic and technological products, etc.), 40% has been claimed in Class 10 (medical instruments, etc.), and 30% for each of Class 5 (pharmaceuticals, etc.) and Class 7 (machines, etc.). Furthermore, the results of the study hint that some classes, including Classes 5, 9, 10, 11, 20, 21, 25, 35, 36, 39, 41, and 42, are likely to be depleted in the near future. Based on these findings, this article offers recommendations for the USPTO and courts to address color concentration and depletion. This study also calls for a reflection and reconstruction of the fundamental justification of trademark law.

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1 In the United States and a number of other countries, applicants may register a color as a trademark if that color serves as a single source identifier and is not used ornamentally or serve a utilitarian purpose. To register a color at the U.S. Patent and Trademark Office ("USPTO"), the applicant must show, inter alia, that the color has achieved secondary meaning and is not functional. *See* Qualitex Co. v. Jacobson Prods. Co., 514 U.S. 159 (1995).

I. INTRODUCTION

Trademark law in the U.S., EU, and UK allows for the registration of single colors as trademarks, such as Louboutin's red shoe sole that contrasts with the upper body of a shoe and Tiffany's use of PANTONE 1837 blue in connection with jewelry. Competition over colors has become intense. For example, in 2014, T-Mobile sued Aio Wireless (Aio, a subsidiary of AT&T) over Aio's use of a plum color (PANTONE 676C, depicted on the right side of Figure 1) for wireless telecommunication services and products.[2] The court granted T-Mobile's Motion for Preliminary Injunction, holding that Aio's plum color was confusingly similar to T-Mobile's registered magenta color (PANTONE Process Magenta, depicted on the left side of Figure 1) and that there is a substantial likelihood of success on the merits of T-Mobile's trademark infringement claim.[3]

Figure 1. Single-color trademarks of T-Mobile and Aio

T-Mobile (plaintiff) Aio (defendant)

Aio resisted T-Mobile's Motion by arguing that all "primary and secondary colors (red, yellow, blue, green, and orange), except violet are owned in the prepaid/wireless space, as most colors had already been claimed by other companies in the sector."[4] As a result, Aio explained that it was exceedingly challenging for it to select a brand color sufficiently distinct from existing ones. Indeed, Verizon claims red, Sprint claims yellow, AT&T claims orange, T-Mobile claims magenta, and Cricket claims green.[5] It is thusly difficult for entrants to find a color that is available and sufficiently distinct from the rainbow of existing color trademarks claimed by competitors. Although the court ruled against Aio, the discussion of Aio's predicament sheds light on the limited color options in the telecommunications sector. Allowing companies to register and claim exclusive rights to use single colors will deplete the available color choices for new entrants in all sectors. This phenomenon is known as "color depletion."

To understand color depletion, we first need to define color. Color is the human visual perception on a segment of the electromagnetic spectrum, with wavelengths from around 0.38 to

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2 T-Mobile US, Inc. v. Aio Wireless LLC, 991 F. Supp. 2d 888 (S.D. Tex. 2014).

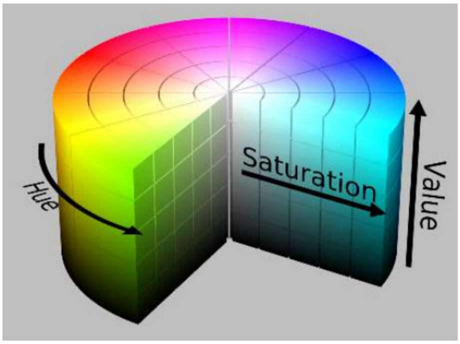
3 *Id.* at 931–32.

4 *Id.* at 901 (quoting Interbrand presentation).

5 *Id.* at 894, 896, 901–02.

0.78 micrometers.[6] Every visible color can be identified by three dimensions: hue, saturation, and brightness (Figure 2).[7] Hue refers to the color category, such as red, orange, yellow, green, blue, etc., represented on a scale ranging from 0 to 360 degrees.[8] Saturation measures how gray or colorful a color is, represented on a scale ranging from 0 to 1.[9] Brightness characterizes how light or dark a color is, also represented on a scale ranging from 0 to 1.[10] The color space can be visualized as a cylinder (Figure 2) measured by these three dimensions.

Figure 2. An HSB (Also Called "HSV") Color Space. (In this figure, "Value" is exchangeable with "Brightness."[11])



Color depletion is a process by which a decreasing number of potential colors remain unclaimed by any trademark owner.[12] In theory, color space can be divided into millions of individual units based on the three dimensions, which would seemingly provide plenty of colors for use by trademark owners. The reality, however, is that human eyes can distinguish between two colors only when their distance in the color space is relatively large. Therefore, distinguishable colors are not infinite and depletion of commercially useful colors is a concern.

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6 Alessandro Bettini, A Course in Classical Physics 4—Waves and Light, 105 (2016).

7 Mohan Lal Gulrajani, ed., Colour Measurement: Principles, Advances and Industrial Applications, 11, 55-56 (Elsevier 2010). There are different coding systems of color: HSB, HSL, PANTONE, LAB, etc. This research uses the HSB code system, which is widely used in psychological research.

8 *Id.* at 55-56.

9 *Id.*

10 *Id.*

11 SharkD, Wikimedia Commons, https://commons.wikimedia.org/wiki/File:HSV_color_solid_cylinder.png (last visited May 17, 2025).

12 *See* Barton Beebe & Jeanne C. Fromer, *Are We Running Out of Trademarks? An Empirical Study of Trademark Depletion and Congestion*, 131 Harv. L. Rev., 945, 950 (2018) (discussing "trademark depletion"); *see also id.* at 977.

In addition, psychological research[13] and anecdotal evidence[14] suggest that companies tend to favor certain colors for branding over others. For example, studies indicate that people generally prefer blue and dislike yellow-green, which might influence company choices regarding trademark colors[15] (see Section II for more details). Therefore, some colors might be "good" for trademarks while others might be "inferior." This preference suggests that "color concentration"—a clustering of trademark registrations in certain color areas—should occur.

Color concentration and color depletion are distinct yet interrelated phenomena. Color concentration may occur when certain colors are preferred disproportionately in business contexts, while color depletion refers to the shortage of available colors. Thus, the very existence of color concentration suggests a risk of color depletion in some color areas; excessive concentration of use and registrations in a business-preferred color area cause a depletion of available colors in that area for new businesses. Therefore, high color concentration can be seen as a manifestation of color depletion within a specific area. Furthermore, the same concern, namely, the anticompetitive costs discussed in the paragraph below, underlies both phenomena. Accordingly, this article will investigate both color concentration and color depletion.

The real concern with color concentration and depletion is not that companies will have no colors left to use or register as trademarks. Rather, the harm is the anticompetitive costs that color concentration and depletion can cause. There are three types of these anticompetitive costs: First, when there is color concentration and depletion, a new entrant incurs additional expenses when selecting a color to ensure that it chooses a color that is far enough from the concentrated areas to avoid conflicts with colors that have already been claimed, but that are not too far from the "good" colors in any given industry.[16] After choosing a color, entrants also may need to design around colors that established users are already using on their own products and services in terms of the shape,

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13 J. P. Guilford & Patricia C. Smith, *A System of Color-Preferences*, 72 Am. J. Psych. 487, 490-491 (1959); Patricia Valdez & Albert Mehrabian, *Effects of Color on Emotions*, 123 J. Experimental Psych.: Gen. 394, 398 (1994); Nilgün Camgöz, Cengiz Yener & Dilek Güvenç, *Effects of Hue, Saturation, and Brightness on Preference*, 27 Color Rsch. & Application 199, 203 (2002) [hereinafter Camgöz, Yener & Güvenç, *Hue, Saturation, and Brightness* (2002)]; Nilgün Camgöz, Cengiz Yener & Dilek Güvenç, *Effects of Hue, Saturation, and Brightness: Part 2: Attention*, 29 Color Rsch. & Application 20, 25 (2004) [hereinafter *Hue, Saturation, and Brightness: Part 2: Attention* (2004)]; Lauren I. Labrecque & George R. Milne, *To Be or Not to Be Different: Exploration of Norms and Benefits of Color Differentiation in the Marketplace*, 24 Mktg. Letters 165, 171 (2013);

14 Pacific Coast Condensed Milk Co. v. Frye & Co., 85 Wash. 133, 142, 147 P. 865, 869 (1915).

15 Camgöz, Yener & Güvenç, *Hue, Saturation, and Brightness (2002), supra* note 13.

16 Beebe & Fromer, *supra* note 12, at 951.

contour, or location of the color to distinguish further from colors that are already in use or registered. This selection and design process requires entrants to invest more resources—whether money or time—than incumbents.

Second, there may be added costs associated with establishing a trademark using "inferior" colors.[17] When the business-preferred color areas are crowded, some entrants have to settle for "inferior" colors.[18] Therefore, entrants need to devote more efforts than incumbents to develop an "inferior" color into a good trademark, which may involve more advertising expenses or longer periods of usage.[19]

Third, entrants may face legal costs associated with potential conflicts with incumbents. These costs might include the risk of trademark registration refusals from the USPTO, the expense of responding to cease-and-desist letters, or even litigation. Theoretically, the higher the costs invested in selecting a color and designing around it (the first type of cost), the lower the cost needed in developing the color into a trademark (the second type of cost). Likewise, higher costs devoted to the first and second types can mitigate the legal costs (the third type of cost).

Despite these costs, the U.S. Supreme Court claimed in *Qualitex* (1995) that color depletion is only "an occasional problem" and dismissed color depletion as an argument for disproportionately instituting a blanket ban against single-color trademarks.[20] Academic scholars are split on whether color depletion is a real concern.[21] Some scholars have argued that color depletion is not a real concern while others argue that color depletion occurs and should not be ignored (Details in Section III).

Which side is correct? Unfortunately, there is a lack of empirical research on this issue. Both judicial practice and academic debates reveal a gap between the theory of color depletion and the lack of empirical evidence to prove or disprove it. The research examined in this article seeks to bridge this gap.

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17 *Id.* at 1021–29; Stephen L. Carter, *The Trouble with Trademark*, 99 Yale L. J. 759, 769-774 (1989).

18 Beebe & Fromer, *supra* note 12.

19 Carter, *supra* note 17.

20 Qualitex Co. v. Jacobson Prods. Co., 514 U.S. 159, 168 (1995).

21 J. Christopher Carraway, *Color as a Trademark under the Lanham Act: Confusion in the Circuits and the Need for Uniformity*, 57-Aut Law & Contemp. Probs. 243 *passim* (1994); Ann Bartow, *The True Colors of Trademark Law: Greenlighting a Red Tide of Anti Competition Blues*, 97 Ky. L.J. 263, 286–89 (2008); Beebe & Fromer, *supra* note 12, at 977; Christopher C. Larkin, Qualitex *Revisited*, 94 Trademark Rep. 1017, 1017, 1025–29 (2004); Elizabeth A. Overcamp, *The* Qualitex *Monster: The Color Trademark Disaster,* 2 J. Intell. Prop. L. 595, 616-617 (1995); Craig Summerfield, *Color as a Trademark and the Mere Color Rule: The Circuit Split for Color Alone*, 68 Chi.-Kent L. Rev. 973, 994–98 (1993); Lauren Traina, *Seeing Red, Spending Green: The Costly Process of Registering and Defending Color Trademarks*, 87 S. Cal. L. Rev. 1319, 1329-1331 (2013).

This research quantitatively analyzes 854 single-color trademark filings on the registers of the USPTO from 2003 to 2019.[22] This research focuses on two empirical questions: (1) does color concentration exist in trademark registrations, and if so, which color areas are more concentrated? (color concentration) and (2) what is the current status of color depletion, and how rapidly might we deplete the color space? (color depletion).

The study's findings reveal high concentrations in certain color areas. For example, 22% of single-color trademark filings are in the red hue segment (hue 345-15). Moreover, 91% of single-color trademark filings appear in color areas with high brightness (brightness > 0.5), while 61% are found in areas with both high brightness (brightness > 0.5) and high saturation (saturation > 0.5). Trademarks can be registered in connection with goods and services falling within some 45 classes of goods/services in the United States.[23] Looking at color concentration in specific classes reveals concentrations in red (hue 246-15), orange (hue 16-25, 46-55), yellow (hue 56-65), and green (hue 96-155) color areas in Classes 7, 9, 10, 11, and 35. The findings show obvious color concentration in registrations and resulting potentially anticompetitive costs to avoid these concentrations within the current trademark registration system.

The estimation of color depletion presented in this research is explorative, but still offers insights into the status of color depletion and how quickly we might deplete the color space in different classes. Among the 45 classes, four classes (Classes 5, 7, 9, and 10) have depletion percentages above 30%, which means that 30% of the color space has been claimed. Some classes (Classes 5, 9, 10, 11, 20, 21, 25, 35, 36, 39, 41, and 42) are projected to reach 100% depletion by 2050 based on the current division of the color space and the rate of adoption of color marks in those classes. This projected schedule implies the anticompetitive costs might become substantial in the near future.

Based on these findings, this author suggests several strategies to mitigate color concentration and depletion: (1) standardizing and monitoring single-color trademark applications, (2) adopting heavier auditing in those highly-concentrated and rapidly depleted areas, (3) increasing the maintenance/renewal fees in highly concentrated and rapidly depleted areas, and (4) allowing for greater similarity between single-color trademarks in highly concentrated and rapidly depleted areas. Finally, the findings,

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[22] The study excluded single-color trademark filings before 2003 because there were very few trademark filings before that year. It also did not collect single-color trademarks filed after 2019, as the pandemic had affected trademark filing after 2019. The single-color trademark filings after 2019 might not represent normal trends.

[23] U.S. Patent & Trademark Office, *Goods and Services*, USPTO.gov, https://www.uspto.gov/trademarks/basics/goods-and-services (last visited May 17, 2025).

together with other empirical research, challenge a fundamental justification of trademark law: symbols are unlimited and equally good to be trademarks. This article calls for a re-examination and refinement of the justification for allowing exclusive rights in color.

This research is the first quantitative exploration into color concentration and depletion. Its contributions lie in three key aspects. First, it fills the gap between the theory of color depletion and the lack of supporting empirical evidence. The findings provide quantitative insights into color concentration and depletion across product and service classes. These findings are valuable for trademark scholars seeking to advance trademark theories and for regulators aiming to understand the potential costs associated with the trademark registration system. Second, this research is the first to use Python programming to code and analyze color trademark specimens (images) recorded by the USPTO. This methodology may inspire other empirical researchers who need to process and analyze large volumes of image data when researching their legal topics. Third, based on the empirical findings, this research proposes specific policy recommendations to the USPTO and courts to mitigate color concentration and depletion and the effects thereof.

Section II reviews psychological and market research on colors; such research implying that there might be lots of colors available, but that they may not all be equally "good" colors to serve as trademarks. Therefore, color concentration might tend to exist more often in "good" color areas. Section III covers the law of single-color trademarks in the United States. It also discusses U.S. court opinions and academic debate on color depletion. Section IV explains the methodology of this research. Section V presents the results, which suggest that color concentration and depletion should be substantial concerns for trademark stakeholders, at least within certain classes of goods and services and certain hue segments. Section VI puts forth policy recommendations to mitigate the anticompetitive costs brought by color concentration and depletion and reflects on a fundamental assumption of trademark law. Finally, Section VII outlines the limitations of this research and proposes directions for future research.

II. RELEVANT PSYCHOLOGICAL RESEARCH AND COLOR CONCENTRATION

As mentioned in the Introduction, every visible color can be identified by three dimensions: hue, saturation, and brightness. Psychological research implies that not all colors are equally good as trademarks: consumers prefer colors in specific hue segments with certain saturation and brightness.

Although there is no specific uniform standard as to what makes a "good" color as a trademark, brand owners often base their color trademark choices on consumer reactions to colors.[24] Therefore, consumer preference and attention play a significant role in determining whether a color is considered "good." A good color trademark should easily capture consumer attention and please them.

Psychological studies have shed light on color preferences. The most popular color among consumers is blue;[25] the least favored is yellow-green.[26] People tend to favor colors with high brightness over those with low brightness and prefer colors with high saturation over those with low saturation.[27] Moreover, brightness has a more substantial impact on human pleasure than saturation.[28] These studies show that changing brightness has larger impacts on human pleasure than changing saturation.

When it comes to consumer attention, empirical studies have shown that colors with high saturation and brightness tend to evoke greater attention than colors with low saturation and brightness.[29] However, the effects of specific hues on attention have been inconsistent. One study suggests that cyan attracts more attention,[30] while another research indicates that green-yellow elicits higher attention.[31] Additionally, warm hues such as red, orange, and yellow capture more attention than cold hues such as blue and purple.[32]

One study analyzed 281 logos in use in the U.S. across 15 product categories and 40 subcategories.[33] This study found that the

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24 *How to Choose Your Brand Colors*, Canva, https://www.canva.com/learn/choose-right-colors-brand/ (last visited May 17, 2025); Mary Kate Miler, *How To Choose A Color For Your Logo: The Ultimate Cheat Sheet* (May 8, 2024), https://foundr.com/articles/building-a-business/best-logo-colors; *Color psychology: The logo color tricks used by top companies—and how to design your own*, Canva, https://www.canva.com/logos/color-psychology-the-logo-color-tricks-used-by-top-companies/ (last visited May 17, 2025).

25 Valdez & Mehrabian, *supra* note 13, at 398; Camgöz, Yener & Güvenç, *Hue, Saturation, and Brightness* (2002), *supra* note 13, at 203.

26 Camgöz, Yener & Güvenç, *Hue, Saturation, and Brightness* (2002), *supra* note 13, at 203.

27 Camgöz, Yener & Güvenç, *Hue, Saturation, and Brightness* (2002), *supra* note 13; Camgöz, Yener & Güvenç, *Hue, Saturation, and Brightness: Part 2: Attention* (2004), *supra* note 13; J. P. Guilford, *The Affective Value of Color as a Function of Hue, Tint, and Chroma*, 17 J. Experimental Psych. 342, 369 (1934); Guilford & Smith, *supra* note 13, at 490–91; Gerda Smets, *A Tool for Measuring Relative Effects of Hue, Brightness and Saturation on Color Pleasantness*, 55 Perceptual & Motor Skills 1159, 1163 (1982); Valdez & Mehrabian, *supra* note 13.

28 Valdez & Mehrabian, *supra* note 13, at 398.

29 Camgöz, Yener & Güvenç, *Hue, Saturation, and Brightness: Part 2: Attention* (2004), *supra* note 13. *Id.* at 398.

30 Camgöz, Yener & Güvenç *Hue, Saturation, and Brightness: Part 2: Attention* (2004), *supra* note 13.

31 Valdez & Mehrabian, *supra* note 13, at 403.

32 Faber Birren, Color & Human Response (1978); Klaus Warner Schaie & Robert Heiss, Color and Personality (1964).

33 Labrecque & Milne, *supra* note 13, at 168.

most frequently used hues in logos are blue (48.2%), white (39.3%), red (31.4%), and black (26.1%), with color preferences varying significantly by industry.[34] For example, in alcoholic beverages, red is the most frequently used hue.[35] In fast food, red, yellow, and white are the most preferred hues. In apparel, black is the most frequently used hue.[36] Red is the most popular color for cars.[37] In the field of computers/electronics, blue is preferred.[38] For household products, white is the most used color in logos.[39] In retail, red has the highest usage in logos.[40] Although logo colors are not necessarily single-color trademarks,[41] this research implies that color concentration is most likely to occur around the predominant color in a particular industry or product category.

To sum up, the research implies that colors characterized by high saturation and brightness might be considered "good" colors that brand owners might strive to claim as trademarks. Despite inconsistent findings on what hues are "good," blue and red are repeatedly mentioned as attractive colors in several studies. Accordingly, we would expect that trademark use and registrations would mirror such preferences, potentially resulting in a concentration of trademark usage and registrations in these color areas.

III. SINGLE-COLOR TRADEMARKS AND COLOR DEPLETION

This section will introduce the law of single-color trademarks in the U.S. and how this law might potentially cause color depletion. It will further summarize the judicial opinions and academic debate on color depletion.

A. Single-Color Trademarks and the U.S. Trademark Registration System

Single-color trademarks are one category of trademarks. These trademarks involve the use of a specific color on a good or in connection with a service to indicate its origin or producer. In the case of goods, a single-color trademark pertains to the color applied

34 *Id.* at 171.

35 *Id.*

36 *Id.*

37 *Id.*

38 *Id.*

39 *Id.*

40 *Id.*

41 Color trademarks might be used on logos but not all colored logos are claimed or registered as color trademarks.

to a part of or the entire surface of the item or its packaging,[42] such as the red color used on the outsole of Louboutin high-heeled shoes.[43] For services, a single-color trademark refers to the color utilized on all or part of the materials used for advertisement or the items associated with the rendering of the services.[44] Examples include the brown uniforms of UPS or the use of magenta in T-Mobile's advertisements.[45] A single color must satisfy the requirements of distinctiveness,[46] no conflicts with earlier marks,[47] and non-functionality to be eligible for registration,[48] just like other categories of trademarks. Further details of these requirements are provided in the footnotes 46, 47, and 48.

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42 TMEP § 1202.05.

43 Christian Louboutin S.A. v. Yves Saint Laurent Am. Holding, Inc., 696 F.3d 206, 212 (2d Cir. 2012).

44 TMEP § 1202.05.

45 *See* U.S. Trademark Registration No. 2159865 (UPS brown color trademark applied to clothing); U.S. Trademark Registration No. 5706644 (Deutsche Telekom AG's magenta color trademark).

46 Distinctiveness is a symbol's ability to distinguish a unique supplier's goods or services from those of others. *See* Two Pesos, Inc. v. Taco Cabana, Inc., 505 U.S. 763, 768 (1992). A symbol, regardless of words, logos, designs, colors or a combination thereof, can be protected as a trademark only when it is distinctive. 15 U.S.C. § 1127, 1052. Distinctiveness can either be inherent in the mark (inherent distinctiveness) or acquired through market usage and promotion (acquired distinctiveness or secondary meaning). *See Two Pesos*, 505 U.S. at 768–69. For example, PEPSI is inherently distinctive because the word is made up and has no connection with any objects except the soft-drink supplier. The egg-blue color is not inherently distinctive as it did not link with Tiffany at the beginning, but through usage and promotion, this color became associated with Tiffany and therefore established the secondary meaning in consumers' minds. So the egg blue color has acquired distinctiveness after extensive use and promotion and is eligible for trademark protection. *See also* Abercrombie & Fitch Co. v. Hunting World, Inc., 537 F.2d 4, 10 (2d Cir. 1976).

47 To register, a mark must not resemble an earlier registered mark, as the co-existence of two similar/identical marks in connection with similar goods or services would be likely to cause consumer confusion as to the source of the product. 15 U.S.C. § 1052(d).

48 Functionality is a doctrine used in the U.S. to prohibit trademark protection when such protection might hinder competition. If the USPTO determines that a mark is functional, it will deny registration. Functionality includes utilitarian functionality and aesthetic functionality. Utilitarian function means a symbol or product feature is essential to the use or purpose of the product; or affects the cost or quality of the product. *See* TrafFix Devices, Inc. v. Marketing Displays, Inc., 532 U.S. 23 (2001). An example of utilitarian function is the shape of a football. The shape has a utilitarian function and cannot be a trademark because footballs rely on the shape to perform their function and trademarking this shape will deprive the rights of competitors to produce a football. Aesthetical functionality refers to a symbol or product feature that is attractive in the aesthetic sense so that trademarking it might impose disadvantages to competitors. *See* Qualitex v. Jacobson Products, 514 U.S. 159 (1995). For example, a spoon with a Baroque-style handle might be considered as aesthetically functional as the design is attractive to many consumers. If one company claims trademark rights on the Baroque design of the spoon handle, other companies cannot use the same/similar design in cutlery market to freely compete. *See* Wallace Int'l Silversmiths, Inc. v. Godinger Silver Art Co., 916 F.2d 76 (2d Cir. 1990).

Both U.S. courts and the USPTO regard single-color marks as lacking inherent distinctiveness.[49] This means that if a brand owner wants to claim trademark rights in a single color, either through registration or litigation, it must provide evidence that the color has acquired distinctiveness. Without evidence proving acquired distinctiveness, a brand owner can still register such a color on the Supplemental Register, which is a Register for trademarks that are not distinctive but that are nevertheless capable of distinguishing goods or services.[50] A registration on the Supplemental Register, while without the advantages of a registration on the Principal Register, such as nationwide trademark protection and prima facie evidence of trademark rights in litigation,[51] may serve as a potential obstacle—or at least notice—to later applicants and their applications.[52] Therefore, this research collected single-color trademark filings on both Registers.

The protective scope of single-color trademarks is limited by how the color is applied to products or services. Applicants must precisely define the context of the color in their color trademark application.[53] And a registered color will not block a later registration of the same or similar color if the later registration claims the color in a different context, namely, a different position, contour, or shape, that distinguishes it sufficiently from the first color.[54] This restricted protection reduces color conflicts and somewhat downgrades color depletion, which will be further explained in Section III.B.2 and Section VII.B.

In addition, single-color trademarks used on one product might not prevent the same color from being used on another unrelated product. Therefore, this research investigates color depletion and concentration within each product category. The USPTO currently adopts the "Nice Classification," which categorizes products and

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49 TEMP 1202.05; *Qualitex*, 514 U.S. at 162–63; Wal-Mart Stores, Inc. v. Samara Bros., 529 U.S. 205, 211–12, (2000); *In re* Thrifty, Inc., 274 F.3d 1349, 1353 (Fed. Cir. 2001).

50 15 U.S.C. §§ 1091, 1094.

51 15 U.S.C. §§ 1057(b), (c).

52 Application of Clorox Co., 578 F.2d 305, 308 (C.C.P.A. 1978). The USPTO has rejected several later trademark applications for the Principal Register by citing earlier marks on the Supplemental Register. For example, the trademark registration with Serial No. 77029015 in the Supplemental Register prevented registration on the Principal Register of the trademark with Serial No. 77106100. The trademark with Serial No. 77124981 on the Supplemental Register blocked registration on the Principal Register of the trademark with Serial No. 85029983.

53 TMEP § 1202.05(c). This provision indicates that when seeking registration for a single-color trademark, the applicant must provide a detailed description of the color's context—how and where the color is used on a particular product or item related to the service. Abstract claims of color without defining its context are not permitted. This is because a color in abstract without context opens the door for multiple trademarks in one application, which would lead to overbroad protection that is undesired.

54 Christian Louboutin S.A. v. Yves Saint Laurent Am. Holding, Inc., 696 F.3d 206, 228 (2d Cir. 2012).

services into 45 classes.[55] Trademark owners must register their trademarks in connection with specific products or services in one or multiple classes.[56] Goods and services within the same class are likely to be more related than those in different classes because "the purpose of the Nice Classification is to group, as much as possible, like goods or services in a single class."[57] Consequently, a single color registered in one class is more likely to block the later applications in the same class. So, this research regards each class as a unit to investigate color concentration and depletion. However, some goods or services within the same class may be unrelated. Section VII.A will further explain this situation.

In the United States, trademark rights arise under common law upon use of a mark in commerce. As a result, common law protects trademarks in the United States that are in use, but that are not registered.[58] U.S. law encourages federal trademark registration by giving additional advantages to registered trademarks over unregistered trademarks, such as by providing nationwide protection and more effective remedies for infringement.[59] This research examines only trademarks registered (and applications for registration) at the USPTO since there is no database recording unregistered color trademarks. Because of this limitation, actual color depletion might be more severe than what is predicted in this research.

B. Judicial Treatment and Academic Debates on Color Depletion

The U.S. Supreme Court held in Qualitex (1995) that color depletion is merely "an occasional problem."[60] This holding stands in contrast to observations by several lower courts that have considered color depletion to be a real concern.[61] Scholars are also

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55 U.S. Patent & Trademark Office, *Nice Agreement current edition version*, USPTO.gov, https://www.uspto.gov/trademarks/trademark-updates-and-announcements/nice-agreement-current-edition-version-general-remarks (last visited May 17, 2025). For instance, Class 9 includes electronic products and other instruments for scientific or research purposes like laptops computers and smartphones, while Class 7 encompasses includes machines, machine tools, motors, and engines.

56 U.S. Patent & Trademark Office, *Trademark scope of protection*, USPTO.gov, https://www.uspto.gov/trademarks/basics/scope-protection (last visited May 17, 2025).

57 TMEP § 1401.11.

58 15 U.S.C. § 1125(a); Two Pesos, Inc. v. Taco Cabana, Inc., 505 U.S. 763, 767–68 (1992).

59 15 U.S.C. §§ 1057(b), (c); 15 U.S.C. § 1065; 15 U.S.C. § 1115(b); 15 U.S.C. § 1117.

60 *Qualitex*, 514 U.S. at 168.

61 Diamond Match Co. v. Saginaw Match Co., 142 F. 727, 729–730 (6th Cir. 1906); Pacific Coast Condensed Milk Co. v. Frye & Co., 85 Wash. 133, 142, 147 P. 865, 869 (1915); Campbell Soup Co. v. Armour & Co., 175 F.2d 795, 798 (3d Cir. 1949), *abrogated by Qualitex Co.*, 514 U.S. at 159 (quoting *Pacific Coast Condensed Milk*, 85 Wash. at 142, 147 P. at 869).

split on whether color depletion is a real concern. The empirical research set out in this article was needed.

1. The Court Opinions on Color Depletion

Early cases evidence that U.S. courts have long been concerned by color depletion. Based on the color depletion theory, some courts rejected the idea of conferring trademark status to a single color. In *Diamond v. Saginaw* (1906), the U.S. Sixth Circuit Court of Appeals reasoned that "[t]he primary colors, even adding black and white, are but few. If two of these colors can be appropriated for one brand of tipped matches, **it will not take long to appropriate the rest**." (emphasis added).[62] In *Pacific Coast Condensed Milk v. Frye & Co.* (1915), which involved a specific color used on milk, the court found that "[t]he primary colors are few, and as the evidence shows those suitable for light products, such as milk, are even more limited. **To allow [the colors] to be appropriated as distinguishing marks would foster monopoly by foreclosing the use by others of any tasty dress**." (emphasis added).[63] In *Campbell Soup v. Armour* (1949), the plaintiff Campbell claimed trademark rights on food container labels that were half red and half white. The court refused this claim and explained that if the plaintiff may "monopolize red in all of its shades **the next manufacturer may monopolize orange in all its shades and the next yellow in the same way. Obviously, the list of colors will soon run out**." (emphasis added).[64] The same color depletion theory was also supported in *First Brands* (1987)[65] and *R.L. Winston* (1993).[66]

The first significant attack on the color depletion theory was *In re Owens-Corning* (1985), in which the Trademark Trial and Appeal Board held that, "in a case where there is no competitive need (whether characterized as 'aesthetic' or otherwise) for colors to remain available to all competitors, the color depletion argument is an unreasonable restriction on the acquisition of trademark rights."[67] The Supreme Court shared the same opinion in *Qualitex*.[68]

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62 *Diamond,* 142 F. at 729 (emphasis added).

63 *Pacific Coast Condensed Milk,* 85 Wash. at 143, 147 P. at 869 (emphasis added).

64 *Campbell Soup*, 175 F.2d at 798 (emphasis added).

65 First Brands Corp. v. Fred Meyer, Inc., 809 F.2d 1378, 1382–83 (9th Cir. 1987).

66 R.L. Winston Rod Co. v. Sage Mfg. Co., 838 F. Supp. 1396, 1400 (D. Mont. 1993).

67 *In re* Owens-Corning Fiberglas Corp., 221 U.S.P.Q. 1195, 1198 (T.T.A.B. Apr. 13, 1984).

68 Qualitex Co. v. Jacobson Prods. Co., 514 U.S. 159, 168–69 (1995). One possible reason of this change of view on color depletion is that the blanket ban based on color depletion did not match the need of companies to use any type of symbols to promote their brands. Section 45 of the Lanham Act (1946) defined a trademark as "any word, name, symbol, or device or any combination thereof . . .," which reflects this business need. Since the Lanham Act (1946), Federal Circuits have become less concerned on color depletion. The Supreme Court simply affirmed this trend in *Qualitex*.

In that case, the plaintiff claimed trademark rights on a golden-green color used on the surface of press pads for dry cleaning, and asserted that the defendant's use of the same color on a competing product was infringement.[69] The defendant argued color depletion to defend its actions.[70] The defendant argued that in any particular industry, "only some colors are usable."[71] Removing unusable colors and registered colors, "one is left with only a handful of possible colors."[72] The Supreme Court rejected the defendant's color depletion argument, claiming that color depletion was only an occasional problem.[73] Therefore, a generalized application of color depletion was unreasonable because "it relies on **an occasional problem** to justify a blanket prohibition."[74] *Qualitex* effectively declared the death of the color depletion theory: post-*Qualitex* cases rarely support or mention the theory of color depletion.[75]

However, the Supreme Court did not have any evidence indicating that color depletion is merely an occasional problem in reality. Similarly, the early cases that had endorsed color depletion pointed to no evidence to support the proposition that color depletion is severe. Again, the empirical research set out in this article was needed.

2. Academic Debate on Color Depletion

Some scholars believe that color depletion is not a significant worry.[76] J. Christopher Carraway contends that there are thousands or millions of colors available for companies to utilize, making color depletion an unlikely scenario in the near future.[77] Researchers have found that human eyes can distinguish around 150 hues, and when considering different shades of each hue, the number of distinguishable colors becomes even larger.[78] As Christopher Larkin and Lauren Traina point out, a color must gain a secondary meaning through use (i.e., to acquire distinctiveness) to

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69 *Qualitex*, 514 U.S. at 159.

70 *Id.* at 168

71 *Id.*

72 *Id.*

73 *Id.*

74 *Id.* (emphasis added).

75 *See, e.g.*, *In re* Haruna, 249 F.3d 1327 (Fed. Cir. 2001); Minnesota Mining & Mfg. Co. v. Beautone Specialties, Co., 82 F. Supp. 2d 997 (D. Minn. 2000); Moldex-Metric, Inc. v. McKeon Prods., Inc., 891 F.3d 878 (9th Cir. 2018); Poly-Am., LP v. Stego Indus., L.L.C., No. 3:08-CV-2224-G, 2011 WL 3206687 (N.D. Tex. July 27, 2011) *aff'd sub nom.* Poly-Am., L.P. v. Stego Indus., LLC, 482 F. App'x 958 (5th Cir. 2012); Leapers, Inc. v. SMTS, LLC, 879 F.3d 731 (6th Cir. 2018).

76 Carraway, *supra* note 21; Larkin, *supra* note 21; Traina, *supra* note 21.

77 Carraway, *supra* note 21, at 262.

78 *Id.*

be protected as a trademark; thereby setting a high threshold for protecting a single color and downgrading color depletion concerns.[79] Traina's research supports this point, showing that single-color registrations did not significantly increase after the *Qualitex* decision.[80] A USPTO official estimated that between the *Owens-Corning* decision in 1985 and the *Qualitex* decision in 1995, the USPTO issued only 30 single-color trademarks registrations.[81] And, as of 2013, there were only 65 single-color trademark registrations.[82]

Another argument against color depletion is that a single color can be concurrently used by several companies if the context of the color (e.g., the positions, contours, or products) differs enough to avoid consumer confusion.[83] Under this argument, protecting a single color as a trademark is not a real concern because the context is critical. This argument discounts the severity of color depletion. There are limited ways to differentiate the positioning, contours, or contexts in which a color can be used on any given product. And, as more companies share the same color, the options for future applicants become more restricted with each new market entrant. Moreover, color depletion does not mean that no colors remain available for entrants to register or use. Color depletion exists as soon as entrants need to adjust the context of their color use to work around existing color trademarks, demonstrating the anticompetitive costs that may arise.

Other scholars argue that depletion might be more severe than estimated.[84] Craig Summerfield argues that although there are more colors than just a few primary hues, the color spectrum is not unlimited and could lead to depletion in specific industries.[85] Ann Bartow and Elizabeth Overcamp posit that while millions of colors exist across the entire spectrum, the number of "good" (business preferred) colors in a particular industry may be limited, potentially causing depletion in specific color categories within certain

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79 Larkin, *supra* note 21, at 1026–29; Traina, *supra* note 21, at 1325-26.

80 Traina, *supra* note 21, at 1329–331.

81 Larkin, *supra* note 21, at 1025 (citing Sachs, *High Court's Ruling May Color Ad Plans*, Advertising Age, Apr. 10, 1995 (quoting Lynne G. Beresford)).

82 Traina, *supra* note 21, at 1329.

83 This argument is based on the limited scope of protection explained in TMEP § 1202.05(c). As explained previously, this provision requests that when registering a color trademark, the applicant must provide a detailed description of the color's context—how and where the color is used on a particular product or item related to the service. This requirement leads to a restrictive protection scope, meaning that one color registration does not block a later similar or identical color if the color context is different.

84 Summerfield, *supra* note 21, at 996-97; Bartow, *supra* note 21, at 263; Overcamp, *supra* note 21, at 616-17; Beebe & Fromer, *supra* note 12.

85 Summerfield, *supra* note 21, at 996–97.

sectors.[86] Barton Beebe and Jeanne Fromer predict that color or word depletion may grow faster than anticipated because once a color or word is protected as a trademark, it could prevent other companies from claiming not only the identical color or word but also many similar colors or words that may cause consumer confusion.[87]

However, color depletion is not just a theoretical issue; it is also an empirical one. Neither the courts, nor current academic debates have quantitative evidence to support their positions regarding color depletion. The following sections will seek to fill this gap by quantitatively and empirically investigating color depletion and color concentration. The study aims to answer the following questions: (1) Does color concentration exist in trademark registrations, and, if so, which color areas are most concentrated? (2) What is the current state of color depletion, and how quickly might we exhaust the available color space?

IV. METHODOLOGY

The methodology for this study is to collect all single-color trademark filings on the USPTO trademark registers and plot them into a three-dimensional (hue, saturation, and brightness) color space. The plotting shows the color areas that have been taken by single-color applications and registrations, based on which this paper estimates color concentration and depletion.

A. Developing the Color Space

One challenge is developing the color space. The color space is a continuous space (see Figure 3 (a)), which makes it difficult to estimate how much space has been claimed by single-color trademark filings. To conduct the research, the continuous cylinder-shaped space needs to be divided into countable cells (see Figure 3(b)). This study uses HSB (hue, saturation, brightness) dimensions to divide the continuous color space into a discrete color space containing many cells (see Figure 3 (a) and (b)).

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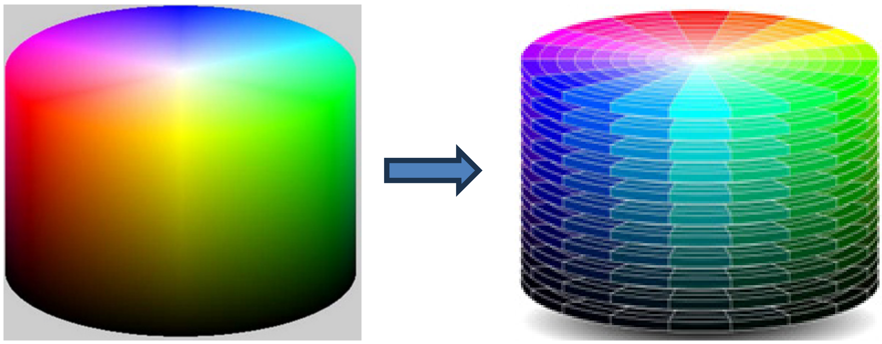
86 Bartow, *supra* note 21, at 263; Overcamp, *supra* note 21, at 616–17.

87 Beebe & Fromer, *supra* note 12, at 979.

Figure 3. Transformation of the Color Space[88]



(a) **(b)**

Each color cell should be sufficiently distinctive to average consumers; that is, it should represent a single, distinguishable color from the perspective of a consumer.

This means the size of a single cell should be neither too large to cover two distinguishable colors, nor too small to have one distinguishable color extending across two cells. So far, however, no scientific research exists to tell us the correct cell size based on a consumer perspective. Thus, this research must establish the proper size of each cell. To do so, the color space is first cut along the cue dimension of the cylinder, and then along the saturation and brightness dimensions separately. The steps are as follows:

1. Step 1: Dividing the Hue Dimension

Figure 4(a) illustrates that distinguishable colors are not evenly distributed across the 360-degree hue spectrum. For example, there is little visible difference in green hues from hue 96 to 155, as perceived by the human eye. In contrast, the color change in other hue ranges, such as those between green and blue (hue 155-185), is much more noticeable. Therefore, instead of an even division, the hue spectrum should be divided based on perceptible color changes. Where the change between neighboring color areas is hardly sensed, these color areas are grouped into the same hue segment. Where the change is easily visible, those areas should be separated into different hue segments. Following this principle, the hue dimension is divided into 25 hue segments as shown in Figure 4(b).

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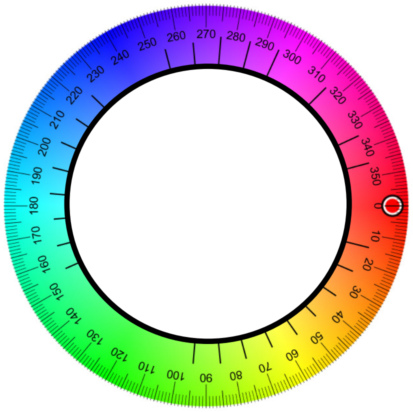
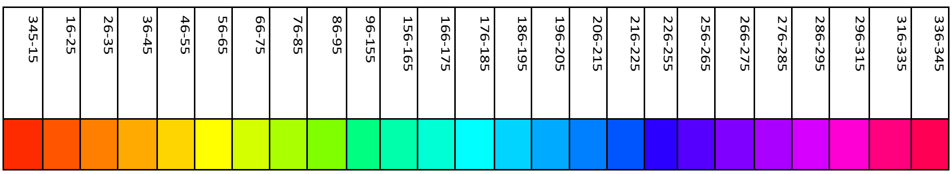
88 Figure 3(a) is developed based on Fig.1(a) from Tieling Chen, Jun Ma & Zhongmin Deng, *Attributes of Color Represented by a Spherical Model*, 22 J. Elec. Imaging 1, 2 (2013); Figure 3(b) is developed by Ric Mann. *See* Ric Mann, *HSB Color Module (DISCS)*, https://lightcolourvision.org/diagrams/hsb-colour-model-discs-white/ (last visited May 17, 2025).

Figure 4. The Division of the Hue Spectrum[89]



(a)



(b)

An additional assessment indicates that the 25-hue segment division is adequate for the purpose of this research. The details of this additional assessment are in Appendix 1.

2. Step 2: Dividing the Brightness and Saturation Dimensions

Each of the 25 hue segments is further divided into four shades based on brightness and saturation. Figure 5 (a) shows the dimensions of brightness and saturation: The vertical axis represents brightness (0–1), and the horizontal axis represents saturation (0–1).

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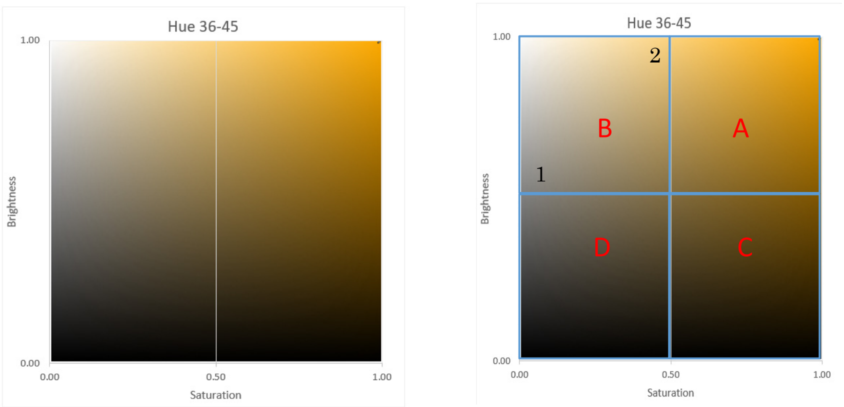
89 In Figure 4(b), most segments cover 10 degrees each (e.g., hue 16-25; hue 26-35; hue 36-45, etc.). However, there are five hue segments that cover more than 10 degrees. The five segments are the red segment (hue 346-15), the green segment (hue 96-155), the dark blue segment (hue 226-255), the magenta segment (hue 296-315) and the plum segment (hue 316-335). The image of Figure 4(b) is made by the author through Microsoft Word. The protractor in Figure 4(a) is made by Clker-Free-Vecotr-Images, Pixabay, https://pixabay.com/vectors/circle-math-education-360-degree-41073/ (last visited May 17, 2025). The color wheel in Figure 4(a) is made by the author through a free online tool. See Development Tools, Color Picker, https://www.developmenttools.com/color-picker/ (last visited May 17, 2025).

Figure 5. Four Shades in the Hue Segment 36-45.



(a) **(b)**

Figure 5(b) displays the divided four shades:

(A) high brightness (0.5–1) with high saturation (0.5–1),

(B) high brightness (0.5–1) with low saturation (0–0.5),

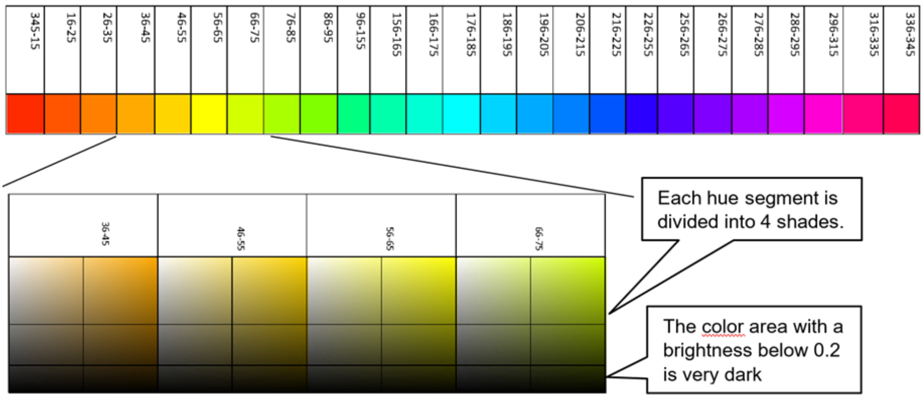
(C) low brightness (0–0.5) with high saturation (0.5–1), and

(D) low brightness (0–0.5) with low saturation (0–0.5).

With close observation, one will notice that spot 1 and spot 2 in Shade B of Figure 5(b) are different. However, further dividing this shade is unnecessary because, in the real market environment, consumers are less likely to have two color trademarks side by side. Instead, they often confront one color, in advertising or stores, and retrieve the other color stored in their brains. In this situation, they are unlikely to discern slight differences in brightness and saturation.

To summarize, for this research, the color space is divided into 25 hue segments, and within each segment, there are four shades (Figure 6). Therefore, the entire color space is divided into 100 cells, making a total of 100 distinguishable colors that companies can use to claim trademarks.

Figure 6. The Summary of the Division



3. The Validity of the Current Division

Although the current division may overlook slight differences within each cell of the 100-cell space, this level of division is reasonable for the current research. First, the distance between the core positions (centroid) of any two cells[90] is even shorter than the distance between color pairs that the USPTO has determined to be similar or the same (Details of this comparison are in Appendix 1). In other words, the current division applies finer color gradations than what the USPTO has applied in practice. Second, the purpose of this research is to estimate the approximate color area that has been taken by single-color trademark filings. Just like predicting the snowing region in weather forecasting, we do not need a high-definition map showing the specific streets and houses. To estimate color concentration and depletion area, we do not need a high-definition map of the color space. A map with reasonably lower definition can achieve the same purpose.

B. Coding and Plotting Single-Color Trademarks into the Color Space

With the 100-cell division of the color space, the next step is to collect all single-color trademark applications and registrations on the USPTO registers, code each such trademark filing, and plot them into the color space. The steps are as follows:

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90 To put it simply, let us consider each cell as a cube, even though it is not. The distance between two cells can be measured by the distance between their centroids. Each centroid has hue, brightness, and saturation values. We can estimate the distance between two cubes using the hue distance, brightness distance, and saturation distance between their centroids, calculated as: $\sqrt{hue\ distance^2 + saturation\ distance^2 + brightness\ distrance^2}$.

1. Collecting Single-Color Trademark Filings

The USPTO's electronic search system allows users to search records of all filed trademark applications and registrations.[91] The USPTO's Design Search Code Manual ("DSCM") provides codes for extracting different types of marks, such as word marks, logo marks, color trademarks, etc.[92] Using the DSCM codes,[93] this study collected a preliminary set of 3,584 single-color trademark applications filed between January 1, 1991, and December 31, 2019.[94]

After sorting, 1,416 single-color trademark filings remain, spanning from 2003 to 2019,[95] of which 854 are alive (registered or pending applications) and 562 are no longer active.[96] This research focuses on the 854 live trademarks, spanning from 2003 to 2019, as the inactive trademarks do not occupy or deplete the color space. The study also includes the drawings for these 854 trademarks in the coding.

2. Coding and Plotting

A computer program using the Python programming language was developed (Appendix 2) to encode the 854 drawings into three dimensions: hue, saturation, and brightness (HSB code). The process is straightforward, as shown in Figure 7: all 854 drawings

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91 U.S. Patent & Trademark Office, *Trademark Search*, USPTO.gov, https://tmsearch.uspto.gov/search/search-information (last visited May 17, 2025).

92 U.S. Patent & Trademark Office, *Design Search Code Manual*, USPTO.gov, https://tmdesigncodes.uspto.gov/ (last visited May 17, 2025).

93 *Id.* The DSCM code system has three parts: xx.xx.xx. The first two numbers represent the design or images of the marks; for example, 03 represents animals, 05 represents plants, and 29 represents trademarks that consist solely of colors. The second two numbers represent how the single color is used: 02 represents a single color used for the entire goods/service; 03 presents a single color used on a portion of the goods; and 04 refers to a single color used on packaging, labels, or signs. The last two numbers represent the hue: 01 represents red or pink, 03 represents blue, etc.

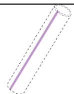
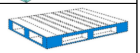
94 Due to coding errors in the USPTO, some trademarks were not considered in the study. These marks include multiple-color trademarks or marks that consist of color(s) but the claimed part is not color related. These marks are not the single-color trademarks relevant to this research. In addition, not all single-color trademarks have color drawings stored in the system. Some early applicants submitted a black and white drawing and described the color as blue, making accurate coding impossible. Also excluded are the gray/silver, white, clear or translucent, and black colors, as they do not fit within the current color space. These colors might be researched separately in the future.

95 After sorting, the registrations before 2003 were removed due to various reasons mentioned above. Consequently, the single-color trademarks analyzed data from 2003 to 2019.

96 The live and dead status of individual trademarks reflects data from April 2020, when the data was collected. Any changes after this date are not considered in this research. However, this does not affect the validity of the study, as post-2020 changes may have been influenced by the pandemic and may not reflect normal trademark application trends.

are input into the Python program, which processes the color in each drawing and generates a unique HSB code for each drawing. This approach ensures that the HSB code of each single-color trademark is accurate, as it is derived from the drawings submitted by the trademark applicants.

Figure 7. The Process of Coding Each Single-Color Trademark[97]

trademark serial number	drawings
74201152	
75541599	
76040552	
….	

Input

trademark serial number	hue	saturation	brightness
74201152	286	0.25	0.79
75541599	175	0.37	0.81
76040552	204	0.74	0.63
….			

Output

With a unique HSB code associated with each single-color trademark, all 854 single-color trademarks are plotted into the 100-cell space. Section V below presents the results.

V. RESULTS

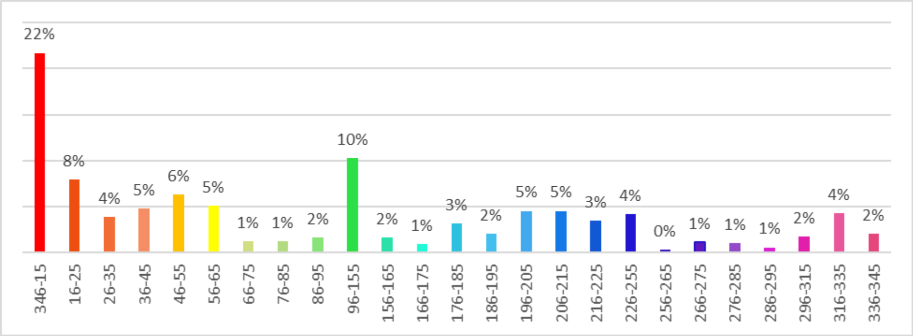
A. Color Concentration

1. Concentration on the 25-Hue Spectrum

Figure 8 displays the distribution of single-color trademarks across the 25-hue spectrum, disregarding saturation and brightness. The percentages in Figure 8 represent the proportions of single-color trademarks registered (or pending for registration) within each hue segment.

[97] The trademark drawings in Figure 7 are downloaded from the USPTO, https://www.uspto.gov/trademarks/search (last visited May 17, 2025).

Figure 8. The Distribution of Single-Color Trademarks Across the 25-Hue Spectrum



This analysis shows that companies tend to prefer the red hue (hue 346-15) for their trademarks (22% of all single-color filings).

This trend is not surprising, as psychological research has shown that red is used in connection with a relatively high proportion (31.4%) of U.S. brands.[98] Moreover, the red hue belongs to warm colors, which are known to attract more attention than cold colors.[99] This attention-capturing advantage could be a reason behind the popularity of adopting red colors.

Interestingly, the green segment (hue 96-155) holds the second highest proportion (10%) of all single-color filings. The popularity of green might be attributed to the recent rise of the green economy, leading more companies to use green to attract environmentally conscious consumers. The previous psychological and marketing research, conducted over a decade ago,[100] might have missed capturing this emerging trend, explaining why the popularity of green went unnoticed in psychological research.

The lower proportion of the blue segments seems to be inconsistent with psychological research, which reveals a public preference for blue.[101] However, this discrepancy can be explained by the fact that blue is a broad color category covering several hue segments (e.g., hues 176-185, 186-195, 196-205, 206-215, 216-225, and 226-255 in Figure 8). When these hue segments are considered together as blue, the overall blue color area accounts for 22%, which is on par with the red segment (22%).

Other segments with lower proportions include the yellow-green segment (hue 66-95), the green-blue segments (hue 156-175), and the purple-magenta-crimson segments (hue 256-315). The

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98 Labrecque & Milne, *supra* note 13, at 170.

99 Birren, *supra* note 32, at 45.

100 Camgöz, Yener & Güvenç, Hue, Saturation, and Brightness: Part 2: Attention (2004), *supra* note 13; Labrecque & Milne, *supra* note 13; Valdez & Mehrabian, *supra* note 13.

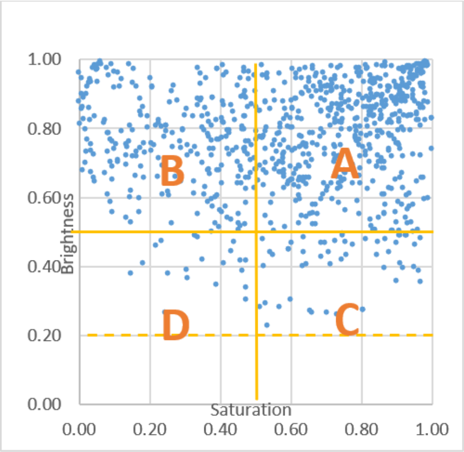
101 *Id.*

unpopularity of the yellow-green segment could be due to its status as the least favored hue according to psychological research.[102] As for the purple-magenta-crimson segments, U.S. culture may perceive these colors as feminine,[103] leading businesses to be careful in using them for branding.

2. Concentration on Brightness and Saturation

When examining brightness and saturation, regardless of hue, 61% of the 854 filings fall in quadrant A (high brightness: 0.5–1 and high saturation: 0.5–1) (Figure 9). Additionally, 30% fall in quadrant B (high brightness: 0.5–1 and low saturation: 0–0.5). Only around 8% fall in quadrants C and D (low brightness 0–0.5). The filings are highly concentrated in high brightness and high saturation (quadrant A). The distribution of single-color trademark filings aligns with psychological research, which indicates that people generally prefer and pay attention to colors with high brightness and high saturation.[104]

Figure 9. The Distribution of Single-Color Trademark Filings on Brightness (X-Axis) and Saturation (Y-Axis)



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102 Valdez & Mehrabian, *supra* note 13, at 203.

103 Some movie posters might contribute to the association between pink, purple, or magenta and females, such as *Breakfast at Tiffany's* (1958), *Pretty in Pink* (1986), *Pretty Woman* (1990), *Legally Blonde* (2001), *Bend it like Beckham* (2002), *Bride Wars* (2009), *Bridesmaids* (2011), and *How to be Single* (2016). Some perfume brands such as DIANA VREELAND, CHANNEL, VERSACE, SHE, ANTONIO BANDERAS, and NEW YANKEES use pink or purple decoration to display female perfumes, while using blue decoration for male perfumes. *See* Shehreen Ataur Khan, *Pink and Blue: Gendered Consumerism*, 8 Crossings: A Journal of English Studies, 120, 122 (2017); Liz Goodgold, Red Fire Branding: Create a Hot Personal Brand and Have Customers for Life (2009).

104 Camgöz, Yener & Güvenç, *Hue, Saturation and Brightness: Part 2: Attention* (2004), *supra* note 13. Valdez & Mehrabian, *supra* note 13, at 398.

In addition, Figure 9 suggests that the impact of brightness to the distribution is larger than that of saturation. If saturation were as influential as brightness, we could expect to see similar registration and application numbers between quadrant B (high brightness: 0.5–1 and low saturation: 0–0.5) and quadrant C (low brightness: 0–0.5 and high saturation: 0.5–1). However, the data shows that quadrant B (30% of registrations) has over four times the number of registrations as quadrant C (less than 8%). This indicates that brightness has a significantly greater impact than saturation. This conclusion is also consistent with the psychological finding that brightness is a stronger factor than saturation in color preference (triggering human pleasure).[105]

Interestingly, there are no single-color trademark filings located in the area below brightness 0.2 (Figure 9). Figure 6 shows that the area below brightness 0.2 is too dark to be seen by consumers, resulting in no registrations in this area.

3. Concentration in the 45 Goods/Services Classes

Figure 10 illustrates that the number of single-color trademarks varies across the different international classes of goods and services. 12% (102/854) of these single-color trademark filings fall into Class 9 (electric and technical products), followed by 11% (92/854) in Class 10 (medical products), 10% (83/854) in class 7 (machines), and 6% (53/854) in Class 5 (pharmaceuticals). These four classes attract around 40% of all single-color trademark filings. In contrast, some classes have very few filings, with less than two for each class: Class 22 (canvas & other materials, etc.), Class 23 (yarns & threads), Class 26 (dressmakers' articles, etc.), Class 27 (floor and wall covers), and Class 34 (tobaccos, etc.).

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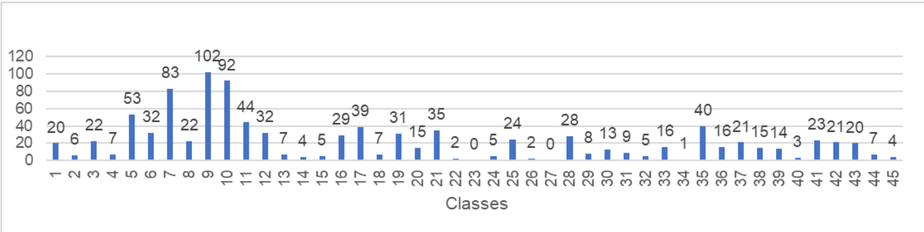
105 Valdez & Mehrabian, *supra* note 13, at 398.

Figure 10. Distribution of Single-Color Trademark Filings Across the 45 Classes



4. Concentration Within Each Hue Segment in Each Class

This section looks into each class to determine which hue segments are the most concentrated in each class.

Table 1 shows the concentration of single-color trademark filings in hue segments across the 45 classes of goods and services. The first column on the left identifies the class. The top row represents the main hues: red, orange, yellow, green, cyan, blue, purple, magenta, and plum. The second row presents the 25 hue segments underlying the main hues. The numbers in the remaining cells of Table 2 represent the number of single-color trademark filings that have been made in each hue segment in each class. The registrations above 10 are highlighted in black and the registrations between 5 and 10 are highlighted in gray. Remember that each hue segment has only four shades—so even just five single-color trademark filings in the same class of related goods or services might have already made that hue segment crowded. As mentioned in Section III above, however, not all goods or services in a class are related, so depending on the specific distribution of the filings across a class, it could also take more—maybe significantly more—than five filings to cause depletion.

Table 1. The Number of Single-Color Trademark Filings Across the 25 Hue Segments and 45 Classes

	red	orange				yellow		green				cyan			blue						purple	magenta			plum
Class	346-15	16-25	26-35	36-45	46-55	56-65	66-75	76-85	86-95	96-155	156-165	166-175	176-185	186-195	196-205	206-215	216-225	226-255	256-265	266-275	276-285	286-295	296-315	316-335	336-345
1	6	1	0	3	1	1	0	0	1	2	0	0	1	0	0	1	0	1	0	0	0	0	0	1	1
2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	1
3	8	2	0	2	0	1	0	1	0	0	0	1	0	0	0	2	1	2	0	0	0	0	0	1	1
4	4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
5	7	2	1	2	2	1	0	3	0	2	0	1	5	5	2	3	1	5	0	0	3	2	0	5	1
6	7	5	1	1	3	1	0	0	1	6	0	0	1	0	1	0	0	0	0	1	0	0	0	3	1
7	19	13	1	3	4	3	1	3	0	9	2	0	0	0	5	6	6	3	0	0	1	0	0	2	2
8	4	6	0	1	2	1	0	0	0	2	0	1	0	0	0	3	0	1	1	0	0	0	0	0	0
9	18	4	6	3	11	10	2	1	2	9	4	0	1	2	5	6	3	2	1	2	0	0	0	9	1
10	9	3	7	3	5	4	0	2	0	15	2	1	3	1	6	5	4	4	0	2	2	0	4	3	7
11	15	1	0	6	2	3	0	0	1	5	0	0	1	0	1	2	2	1	1	0	2	0	0	1	0
12	7	3	1	5	2	2	1	0	1	0	1	0	1	0	2	1	2	2	0	0	0	0	1	0	0
13	2	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0
14	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
15	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
16	5	3	2	3	3	3	1	0	1	0	2	0	3	0	2	1	0	0	0	1	0	0	0	0	1
17	5	5	0	3	2	2	1	0	2	2	1	1	1	1	1	3	4	2	0	1	0	2	0	0	0
18	2	2	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
19	8	0	1	0	2	5	0	0	0	6	0	0	0	0	2	1	2	4	0	0	0	0	0	0	0
20	3	1	1	0	0	1	0	0	1	1	0	0	2	1	0	1	3	1	0	0	0	0	0	0	0
21	8	3	3	0	3	0	1	0	0	7	0	1	2	0	1	1	2	1	0	0	0	0	2	1	1
22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0
25	6	1	2	1	3	0	0	0	1	2	0	1	0	2	0	1	0	0	0	1	0	0	0	1	2
26	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	6	3	2	3	6	1	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	2	1	0
29	3	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
30	2	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	3	0	1	0	0	0	3	0
31	1	1	1	0	3	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
32	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1
33	4	1	0	1	1	0	1	0	0	1	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0
34	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	12	5	0	0	2	2	1	0	2	7	1	1	1	2	1	1	0	1	0	0	0	0	0	1	0
36	2	1	0	0	1	0	0	0	1	2	1	0	2	1	2	0	0	1	0	0	0	0	0	2	0
37	5	2	1	1	1	0	0	0	1	2	1	0	1	0	1	0	2	0	0	1	0	0	0	2	0
38	5	0	0	0	1	2	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	3	0
39	0	5	1	0	0	2	0	0	0	2	2	0	0	0	1	0	0	0	0	0	0	0	0	1	0
40	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	8	2	2	0	1	1	0	0	1	2	0	0	0	0	1	0	0	2	0	0	0	0	1	2	0
42	5	1	1	1	2	0	1	0	0	2	2	0	0	1	0	1	0	3	0	0	0	0	0	1	0
43	6	0	1	0	0	2	0	1	0	0	0	0	0	1	4	0	0	0	0	0	0	0	1	4	0
44	1	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
45	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Table 1 shows three levels of concentration:

High concentration: In this level, some hue segments have 10 or more single-color trademark filings. As each hue segment has only four shades, the fact that one hue segment has 10 or more single-color trademarks may make each high concentration segment very crowded. Such high concentrations can be seen in:

Class 7 (machines, etc.)	red (hues 346-15), orange (hues 16-25)
Class 9 (electronic goods, etc.)	red (hues 346-15), orange (hues 46-55), yellow (hues 56-65)
Class 10 (medical instruments, etc.)	green (hues 96-155)
Class 11 (apparatus for lighting, cooking, cooling & sanitizing, etc.)	red (hues 346-15)
Class 35 (general business, etc.)	red (hues 346-15)

Middle concentration: At this level, some hue segments have between five and nine single-color trademark filings. Classes 1, 3, 5, 8–12, 16–17, 19, 21, 25, 28, 35, 37–39, and 41–43 have this middle concentration on red, orange, yellow (hues 56-65), green (hues 96-155), cyan (hues 176-185; 186-195), blue (hues 196-205, 206-215, 216-255), magenta (hues 316-335) and plum (hues 336-345). This paper does not list the segments here individually, but they are shown in Table 1.

Low concentration: These hue segments have fewer than five single-color trademarks at this level, meaning that the concentration is low. Classes 2, 4, 13–15, 18, 20, 22–24, 26–27,29–34, 36, 40, and 44–45 are at this low concentration level. Again, this paper does not list the segments here individually, but they are shown in Table 1.

Overall, the concentration of different hue segments varies across different goods and services and the hue, but a high concentration appears mainly in the red hue segment. These results are consistent with findings in Labrecque and Milne's research. For example, in their research, red is popular on alcoholic beverages, which fall within Class 33, and on retail services, which fall within Class 35.[106] Table 1 also shows that the red segment in Classes 33 and 35 has more filings than other color segments in the same classes. However, there are also some inconsistencies between this research and Labrecque and Milne's research. For instance, Table 1 reveals that the red hue is the most popular hue in Class 9 (electronic goods, etc.), while Labrecque and Milne's research suggests that blue would be preferred in connection with computers and electronic goods.[107] This apparent discrepancy could be explained by the fact that their research focused on the colors of entire logos in the market, rather than on single-color trademark

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[106] Labrecque & Milne, *supra* note 13.

[107] *Id.*

filings at the USPTO. In addition, Labrecque and Milne's research used a different classification of goods and services than the Nice Classification system used in this research.

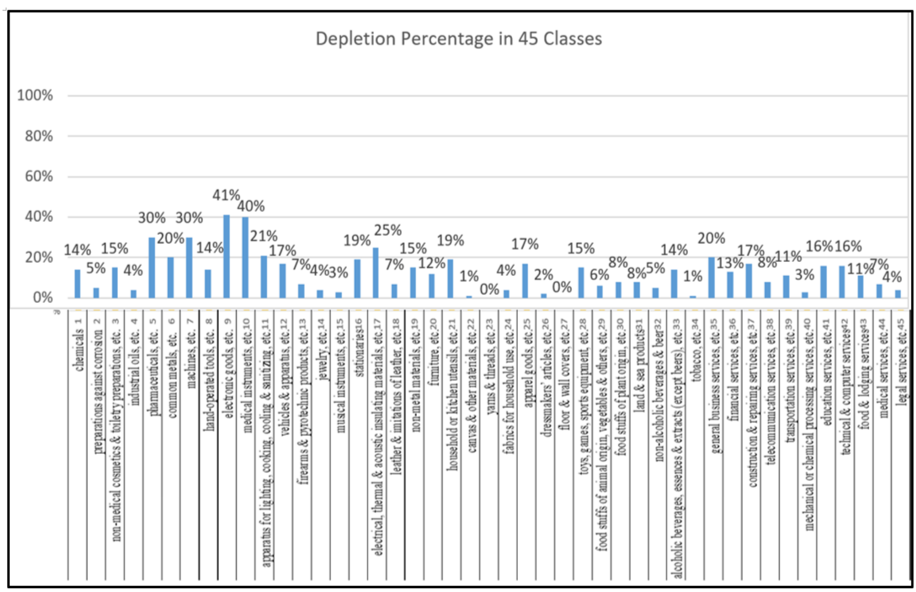
B. Color Depletion

1. Depletion Proportion: How Many of the 100 Cells Have Been Claimed?

This section will analyze the status of color depletion in each good or service class. The basic approach is to plot the single-color trademark filings into the 100-cell space and calculate the percentage of the cells that have been claimed. Appendix 3 explains the details of the method.

Figure 11 indicates the percentages of depletion on the 100-color cell space (x-axis: 45 product or service classes; y-axis: depletion percentages). Each percentage tells the portion of how many cells in the 100-cell space have registrations or pending applications. Four classes of products/services have depletion above 30%: **Class 9 (41%), Class 10 (40%), Class 5 (30%), and Class 7 (30%).** It means that among the 100 color cells, more than one third have been claimed by single-color trademarks in these classes. Although perhaps not severe, the depletions in these four classes could still be substantial, depending on the distribution of the single-color trademark filings in these classes. In the remaining classes, the depletion is lower than 30%, and in many cases in the single digits.

Figure 11. Depletion Percentages Across the 45 Classes



These estimated depletion percentages should be considered explorative rather than conclusive. This is because the depletion percentage is partially influenced by this study's division of the color space into 100 cells. If we were to divide the color space into 1,000 cells, the estimated depletion percentages would likely be lower than those shown in Figure 11. On the other hand, if we were to divide it into 50 cells, the depletion percentages could be higher. However, this estimation is not meaningless. First, as explained in Section IV.A, the division into 100 cells considered consumer's ability in sensing color differences and the USPTO's applied standards in determining color similarity, such that the estimated depletion percentages are reasonable based on the 100-cell division. Second, the estimated depletion percentages provide an indicative view of the depletion situation. These percentages can be seen as conditional estimates. Depending on practical needs, regulators such as the USPTO may adopt predictions that are either more optimistic or more pessimistic than the current estimate. With this in mind, the following section analyzes the estimated depletion speed.

2. Depletion Speed: How Soon Will the 100-Cell Space Be Fully Depleted?

This study used three steps to estimate the rate of depletion: (1) calculating the historic depletion percentage per year based on the data from 2003 to 2019; (2) with the input of historic annual depletion percentages from 2003 to 2019, developing a mathematical function to describe how the depletion percentage changes over the years; and (3) based on this function, calculating or predicting the year when the depletion percentage will reach 100%, namely, the year when all 100 color cells will have been claimed by trademark registrations. For readers who are interested, the methodology details are included in Appendix 4, and the mathematical function and curve figure for each class is listed in Appendix 5.

Figure 12 below hypothesizes how soon the 100-cell space of each class will be depleted. The vertical axis displays the class, and the horizontal axis denotes time. The classes with fully saturated bars show the estimated year when that class will reach 100% depletion. The classes with dotted bars are estimated to reach a plateau below full depletion. For the classes without bars, the dataset contained insufficient information to make a useful projection.

Figure 12. The Prediction of Depletion in 45 Classes

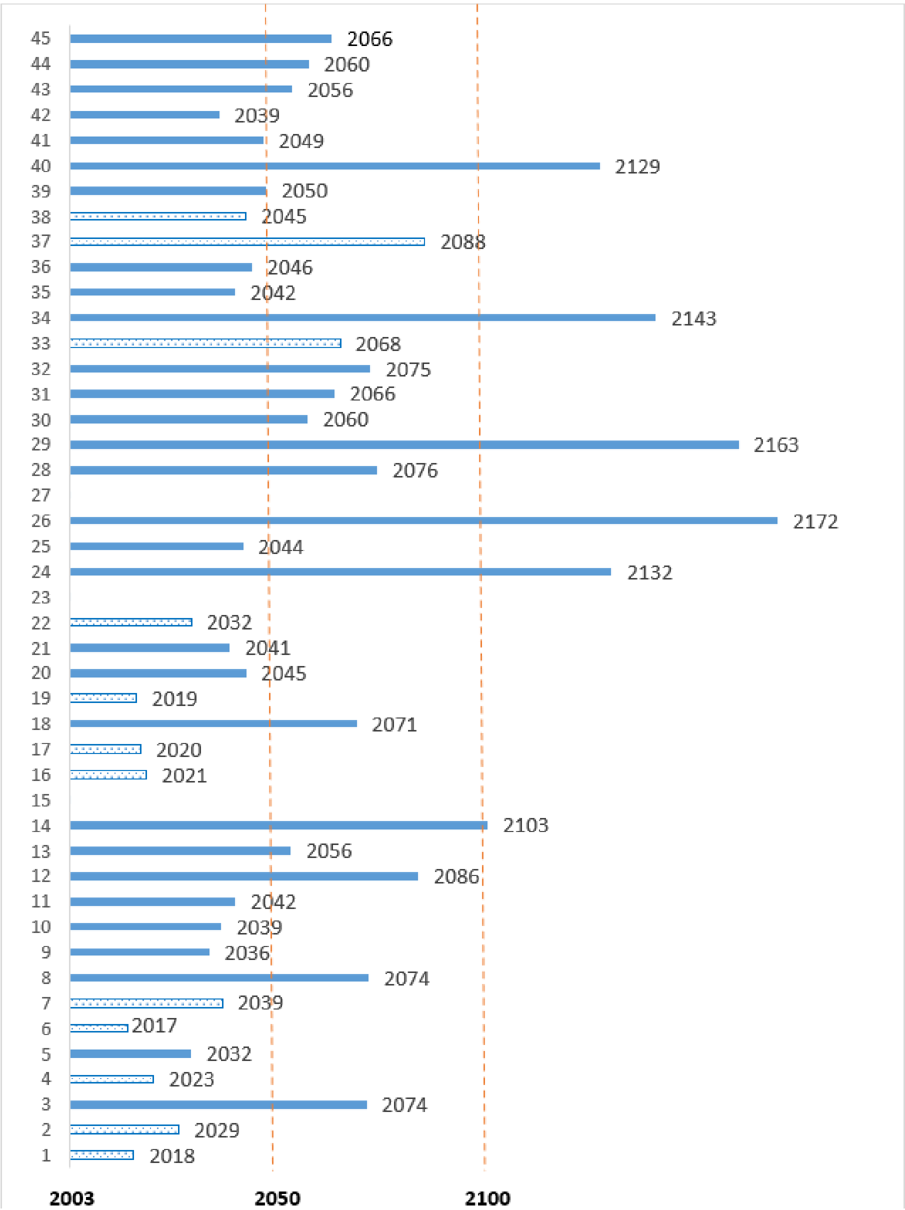


Figure 12 shows that the following classes are estimated to reach full depletion by 2050: Classes 5, 9, 10, 11, 20, 21, 25, 35, 36, 39, 41, and 42 (indicated by the saturated bars in Figure 12). Other classes are estimated to reach full depletion between 2050 and 2100, namely: Classes 3, 8, 12, 18, 28, 30, 31, 32, 43, 44, and 45. The remaining classes (Classes 14, 24, 26, 29, 34, and 40) might reach full depletion after 2100.

As explained in Section V.B.1, this depletion schedule is explorative rather than conclusive, as the depletion percentage and speed are partially influenced by the division of the color space used in this study. Readers might consider this schedule as an indicative map of the future depletion trend based on the 100-cell space. This map is meaningful to trademark regulators such as the USPTO to evaluate color registration dynamics.

In addition, full depletion would not necessarily mean that companies could not register any individual color. The real concern, as previously explained, would be in the increased costs for new entrants—costs for selecting a color, establishing a trademark based on that color, and handling legal conflicts—from the rising color concentration and depletion. The prediction in this study might overestimate the immediacy of 100% depletion, yet the anticompetitive costs could increase before we reach 100% depletion. What the projected schedule suggests is that those costs in the trademark registration system might become substantial—and occur across multiple industries—in the near future, and we should act before it gets that far.

Readers might notice that in Figure 12, Classes 23 and 27 have no estimated date of full depletion. This is because, as of the end of 2019, there were no single-color trademark filings in the two classes (Figure 11), and it is therefore not possible to predict a schedule for these classes. Figure 12 provides no schedule for Class 15 because the data predicts that depletion of this class will take 3.2537×10^{58} years (see Appendix 5) to reach full depletion. It is not useful to show such a long term in Figure 12, and there is no appreciable concern of color depletion in Class 15 with such a long time frame. Furthermore, the estimated schedule of some classes in Figure 12 are shown in dotted bars (Classes 1,2, 4, 6, 7, 16, 17, 19, 22, 33, 37, and 38). The mathematic analysis indicates that these classes will never reach full depletion, which is further explained in Appendix 6.

Lastly, depletion of each of the 45 classes could progress in one of two ways: In some classes, the depletion may increase slowly at first and accelerate later. In other classes, depletion could increase quickly at first and slow later, possibly never reaching 100% depletion. Classes that correspond to each pattern are shown in Table 2. See Appendix 6 for details of the two patterns.

Table 2. The Two Patterns of the Depletion Trend Across the 45 Classes

Patterns	Classes
1. Depletion increases slowly at first and accelerates later	3, 5, 8, 9, 10, 11, 12, 13, 14, 18, 20, 21, 24, 25, 26, 28, 29, 30, 31, 32, 34, 35, 36, 39, 40, 41, 42, 43, 44, and 45[108]
2. Depletion increases quickly at first and slows later, never reaching 100% depletion	1, 2, 4, 6, 7, 16, 17, 19, 22, 33, 37, and 38

C. Summary and Implication

1. Findings and Implications of Color Concentration and Depletion

The research implies that colors are not equally good or preferred as trademarks. Across different goods and services, there is a high concentration of single-color trademark filings in the red hue segment and in the area of high saturation and high brightness. Looking into each class, single-color trademark filings are most highly concentrated in red, orange, yellow, and green in Classes 7, 9, 10, 11, and 35. These hue segments in these classes have more than 10 single-color trademark filings. Given that each hue segment has only four shades (cells), the level of concentration in these areas is quite high.

The scope of depletion also varies among the classes. While some classes show substantial depletion (around 40%), overall, the current level of depletion is not severe. Despite having non-severe depletion percentages, some classes might nevertheless deplete quickly. For example, Classes 5, 9, 10, 11, 20, 21, 25, 35, 36, 39, 41, and 42 could reach full depletion by 2050. In other words, by 2050, new entrants who wish to use or register a single-color trademark in these classes would encounter more difficulties and higher costs, compared to incumbents.

As repeatedly mentioned, these findings of color depletion are speculative rather than conclusive. However, the findings of color concentration are robust because the concentration remains unchanged regardless of how many cells into which the color space

[108] Classes 23 and 27 have zero single-color trademarks and therefore do not belong to either of the two patterns. Class 15 also does not belong to the two main patterns, and therefore, is not shown in this table.

is divided. Color concentration already implies some costs to entrants, such as settling for "inferior" colors, spending more to develop them into trademarks, and undertaking more legal risks. Considering the impact of the robust color concentration findings, along with a conservative approach to the prediction of color depletion, the implied anticompetitive costs in the trademark registration system cannot be ignored. These costs may be even higher in reality, given that studies show that around 40%–50% of trademark registrations in the U.S. are registered in connection with at least some goods or services that are not actually in use.[109] These findings call for actions to address color concentration and depletion and reduce anticompetitive costs.

2. Different Severity Levels of Color Concentration and Depletion

Before proposing specific solutions, distinguishing between the severity levels of color concentration and depletion is crucial for legislators, regulators, and courts to adopt tailored strategies to address color concentration and depletion. As shown in Table 3, the highly concentrated hue segments in those rapidly depleting classes (reaching full depletion by 2050) should be given top priority and addressed first (the black cell in Table 3), namely: red (hues 346-15), orange (hues 46-55), yellow (hues 56-65) in Class 9, green (hues 96-155) in Class 10, red (hues 346-15) in Class 11, and red (hues 346-15) in Class 35.

The second priority is found in the gray cells in Table 3, which represent highly concentrated hue segments in less-depleted classes (reaching full depletion after 2050) and those less-concentrated hue segments in rapidly depleted classes (reaching full depletion by 2050), namely: red (hues 346-15) and orange (hues 16-25) in Class 7 as well as Classes 5, 9, 10, 11, 20, 21, 25, 35, 36, 39, 41, and 42.

The remaining hue segments and classes are of low concern at present (the white cell in Table 3).

109 U.S. Patent & Trademark Office, *Post Registration Audit Program Statistics*, USPTO.gov, https://www.uspto.gov/trademarks/maintain/post-registration-audit-program-statistics (last visited May 17, 2025).

Table 3. The Severity Level of Color Concentration and Depletion

	Highly concentrated hue segments	Less-concentrated hue segments
Rapidly depleted classes (reaching full depletion by 2050)	Class 9: red (hues 346-15), orange (hue 46-55), yellow (hues 56-65) Class 10: green (hues 96-155) Class 11: red (hues 346-15) Class 35: red (hues 346-15)	All hue segments in Classes 5, 9, 10, 11, 20, 21, 25, 35, 36, 39, 41, and 42, except the hue segments listed in the black cell
Less-depleted classes (reaching full depletion after 2050)	Class 7: red (hues 346-15), orange (hues 16-25)	All remaining hue segments in the remaining classes

VI. DISCUSSION AND SOLUTIONS

A. Standardization and Monitoring

It is crucial to regularly capture the status of single-color registrations so that the USPTO can respond timely and strategically. For this reason, the author recommends that the USPTO standardize and monitor color trademark applications as described below.

1. Standardization of Color Identifications

Currently, trademark applicants are not required to provide a specific color code to identify their color, such as an HSB code, but simply to "name[e] the color(s)" being registered.[110] Although applicants must submit a drawing and a description of their color,[111] vagueness often persists. Some descriptions are imprecise and broad, such as "dark blue"[112] or "blue,"[113] and color deviations can occur when drawings are viewed on different computer screens. This vagueness may cause uncertainty and inconsistency in protection

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110 TMEP § 1202.05(e).

111 *Id.*

112 *See* U.S. Trademark Application Serial No. 98405168.

113 *See* U.S. Trademark Registration Nos. 4119742 and 3748644, 5952059; U.S. Trademark Application Serial No. 98308887.

scope. Therefore, requiring the applicant to submit a color code (HSB codes or other code systems) is essential for eliminating ambiguity and standardizing color trademark applications. Color codes would help examiners quickly identify similar earlier color trademark filings. They would also enhance objectivity in deciding whether colors are similar, because with an HSB code, examiners could easily locate the claimed color in a color space and use the color distance with earlier marks as a factor to assess color similarity. Most importantly, color codes would enable the USPTO to monitor color registrations and timely react to areas of severe color concentration and depletion.

This standardization would not impose substantial costs on either applicants or the USPTO. Applicant could get the color codes from their trademark designers. If not, applicants could easily obtain the color code using free online color identification tools.[114] And even if a trademark applicant is not able to get the color code before filing, the USPTO could develop a color identification software application to include in its application system so that when an applicant uploaded the drawing of their color trademark, the application would automatically generate the color code. The app could be developed based on the Python code provided in Appendix 2.

2. Monitoring

With the standardization of color identifications, the USPTO could monitor color trademark filings to capture the dynamics of color depletion and intervene in a timely manner.

The monitoring might include three steps: (1) color coding, (2) color plotting, and (3) analysis and prediction. The USPTO could decide the frequency of the monitoring based on its capacity.

First, the USPTO should obtain the HSB code for each single-color registration. This step would already be realized if the USPTO were to require standardized color identifications for new trademark applications claiming color, as discussed above. If not, this step is not substantially difficult because the USPTO can use a simple software program to code each single-color trademark filing, just as what this study has done (Appendix 2).

Second, with the HSB codes, the USPTO could use the same method as was used in this research (Appendix 3) to plot the single-color trademark filings to the existing color map—i.e., the 100-cell color space. The USPTO may also adjust the number of cells in the

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114 Examples of these free online color identification tools include: Pixelied, https://pixelied.com/colors/image-color-picker (last visited May 17, 2025); Color Picker, https://colorpicker.tools/ (last visited May 17, 2025); RedKetchup, https://redketchup.io/color-picker (last visited May 17, 2025).

color space, using more or fewer than the 100 cells used in this research, based on practical requirements.

Third, using the plotting, the USPTO could estimate color concentration and depletion percentages in each class, just as has been done in this study (methods in Appendix 3 and Appendix 4). These estimations could provide the USPTO with trends of concentration and depletion over time.

If single-color trademark applications are standardized, monitoring would not impose significant additional costs. Also, the frequency of monitoring could be as low as biannually, which would reduce the costs of such a program.

Based on the information obtained from monitoring single-color trademark filings, the USPTO could adopt appropriate strategies to alleviate issues arising from color depletion or concentration, including those discussed in the following sections.

B. Weighted Post-Registration Audit to Remove Non-Used Trademarks

Since 2017, the USPTO has conducted a Post Registration Audit Program (the "Audit") in order to remove non-used trademarks from its registers so that the trademark registers can function as "a reliable reflection of trademarks in use in commerce."[115] Under the Audit, the USPTO chooses certain trademark registrations for review and requires the owners of those registrations to submit evidence of use in commerce for selected goods/services.[116] If the trademark owners fail to submit such evidence, the audit can expand to all goods/services in their registrations, which at minimum will be narrowed to the goods/services on which the mark is actually used.[117] This program releases more space for entrants, reducing trademark concentration and depletion.[118]

However, it appears that the current Audit strategy employs random sampling, without weighting by good/service class or type of mark, and thus without a specific focus on the highly concentrated and depleted color areas.[119] This simple random sampling strategy

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115 U.S. Patent & Trademark Office, *Post Registration Audit Program*, USPTO.gov https://www.uspto.gov/trademarks/maintain/post-registration-audit-program (last visited May 17, 2025).

116 *Id.*

117 *Id.*

118 The USPTO published the audit results from 2019 to 2023. If the Audit works well in clearing unused marks, we expect that the cancellation rates resulting from the Audit will go down over time. Indeed, data published by the USPTO indicates that cancellation rates have declined from around 50%–60% in 2020 to 40%–50% in 2023. *See Post Registration Audit Program*, *supra* note 115.

119 U.S. Patent & Trademark Office, Changes in Requirements for Affidavits or Declarations of Use, Continued Use, or Excusable Nonuse in Trademark Cases, 81 Fed. Reg. 40589,

is less efficient in addressing color concentration and depletion. Therefore, this author suggests weighted sampling—varying the weight of samplings according to depletion levels. Based on the findings of this research, the USPTO might sample most heavily in the concentrated hue segments in rapidly depleting classes (the black cell in Table 3), and perform a mid-size sampling in the highly concentrated hue segments in less depleted classes and those non-concentrated hue segments in quickly depleting classes (the gray cells in Table 3). For the area in the white cell of Table 3, the USPTO might not sample or use the lightest sampling. The weighted sampling might be adjusted based on the findings captured in the proposed regular monitoring.

Beebe and Fromer have suggested weighted sampling to target areas with severe word mark depletion.[120] However, when the USPTO launched its pilot audit program, some commentators expressed concern that the program "is not capable of being applied equally to all 'applicants.'"[121] Responding to these concerns, the USPTO promised that its audits would not "have a disproportionate impact upon any particular class of registrant" through randomly selecting the registrations.[122] The USPTO has softened its stance more recently, though, announcing a new program of "directed audits" aimed at registrations maintained with fabricated specimens, such as "digitally altered" images or specimens from a "specimen farm."[123]

The time has come, therefore, for the USPTO to consider using weighted sampling audits. The evidence of color concentration provided in this article and the word-mark congestion in the research of Beebe and Fromer[124] give objective justification for the USPTO to conduct weighted sampling audits. The purpose of such weighted sampling is not to discriminate against a particular group of trademark registrations, but to reduce the number of registrations on the register for marks that are not in use in highly concentrated areas and to open up more space for entrants.

40590, govinfo.gov (June 22, 2016), https://www.govinfo.gov/content/pkg/FR-2016-06-22/html/2016-14791.htm (last visited May 17, 2025).

120 Beebe & Fromer, *supra* note 12, at 1035.

121 U.S. Patent & Trademark Office, Changes in Requirements for Affidavits or Declarations of Use, Continued Use, or Excusable Nonuse in Trademark Cases, 82 Fed. Reg. 6259, 6261, govinfo.gov (Jan. 19, 2017). https://www.govinfo.gov/content/pkg/FR-2017-01-19/pdf/2017-00317.pdf (last visited May 17, 2025).

122 *Id.*

123 Changes in Post-Registration Audit Selection for Affidavits or Declarations of Use, Continued Use, or Excusable Nonuse in Trademark Cases, 89 Fed. Reg. 85435, 85436 (Oct. 28, 2024).

124 Beebe & Fromer, *supra* note 12.

C. Increasing the Maintenance and Renewal Fees of Trademark Registration

In addition to weighted sampling audits, another way to reduce concentration and depletion is by increasing trademark maintenance and renewal fees in highly concentrated and rapidly depleting areas. This strategy might discourage trademark owners from maintaining non-used trademarks in these areas.

After five years from registration, and then at each 10-year anniversary of registration, the USPTO requires trademark registrants to prove that their mark remains in use and to pay maintenance fees to maintain their registration.[125]

The author recommends raising these maintenance and renewal fees in areas that are concentrated and being quickly depleted.[126] Based on this research, the USPTO could consider three tiers of fees: the highest fees for areas with top priority (the black cell in Table 3), a middle tier for areas with second priority (the gray cells in Table 3), and the lowest fees for areas in the white cell in Table 3, where there is no concern about color concentration or depletion. The amounts of the maintenance and renewal fees could be based on and varied according to the regular monitoring discussed above.

Although increasing maintenance and renewal fees would increase the cost to companies to maintain validly used marks, it would also encourage efficient allocation of limited color resources to companies who will make the most use of them.[127] This finance incentive will force companies to examine whether they indeed need to keep a single-color registration. If the commercial values generated by a color brand is less than the maintenance/renewal fees, a company might decide to abandon its single-color trademark registration. The previously occupied color space could therefore effectively be released to the public, and a new player could re-use the color.

This adjustment is not expected to fully resolve the problems of color concentration and depletion, as the underlying driver is businesses's need to use industry-preferred colors to promote their goods and services. Instead, the adjustment aims to eliminate unused color trademarks that companies are holding, freeing up color space for businesses with genuine needs. Therefore, it is crucial to increase maintenance and renewal fees to a level that

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125 USPTO, *Trademark Fee Information*, USPTO.gov, https://www.uspto.gov/trademarks/trademark-fee-information (last visited May 17, 2025).

126 Beebe and Fromer have also suggested increasing the maintenance and renewal fees to reduce word mark depletion. They further suggested increasing the fee for those areas that have severe depletion while reducing the fees for areas without depletion. Beebe and Fromer, *supra* note 12, at 1030–31.

127 *Cf. id.* at 1031.

discourages the continued registration of unused trademarks while remaining reasonable for businesses that actively use their trademarks.

Implementing a variable fee policy might increase the USPTO's administrative costs to some extent, but considering the USPTO's current fee practices, a variable fee to address depletion and concentration would not be wholly impractical. Every other year, the USPTO reviews and updates various trademark fees, including maintenance and renewal fees.[128] In the past, the USPTO had varied its trademark fees to discourage or encourage certain behaviors. For example, to discourage paper filing, it increased the renewal fee from $400 to $500[129] for paper filing, while reducing the renewal fee from $400 to $300 if the applicant filed the renewal online.[130] Further, to cover increased examination costs, the USPTO has increased maintenance fees three times, from $100 to $125[131] in 2017, to $225[132] in 2021, and to $325 in 2025.[133] As such, it is practical for the USPTO to adjust renewal and maintenance fees to achieve policy purposes such as reducing color or trademark depletion.

One might suggest also increasing the initial application fee that the applicant needs to pay when applying for registration. The author disagrees with this suggestion for several reasons. First, increasing the application fee targets only new entrants, which will increase barriers to entry.[134] Second, using maintenance/renewal fees as a policy tool will be more effective than using application fees. The maintenance/renewal fees are first paid five years after registration. Initially, a company does not know whether their color brand will become valuable and worth the application fee when they register it. But they will know the value of their brand five years

128 U.S. Patent & Trademark Office, *Summary of FY 2021 Final Trademark Fee Rule*, USPTO.gov, https://www.uspto.gov/trademarks/laws/updated-trademark-ttab-fees-processes (last visited May 17, 2025); U.S. Patent & Trademark Office, *Summary of 2025 trademark fee changes,* USPTO.gov, https://www.uspto.gov/trademarks/fees-payment-information/summary-2025-trademark-fee-changes (last visited May 17, 2025).

129 U.S. Patent & Trademark Office, Trademark Fee Adjustment, 81 Fed. Reg. 72694 (Oct. 21, 2016), https://www.federalregister.gov/documents/2016/10/21/2016-25506/trademark-fee-adjustment (last visited May 17, 2025).

130 U.S. Patent & Trademark Office, Reduction of Fees for Trademark Applications and Renewals, 79 Fed. Reg. 74633 (Dec. 16, 2014), https://www.federalregister.gov/documents/2014/12/16/2014-29413/reduction-of-fees-for-trademark-applications-and-renewals (last visited May 17, 2025).

131 *Trademark Fee Adjustment*, *supra* note 129.

132 U.S. Patent & Trademark Office, *Summary of FY 2021 Final Trademark Fee Rule*, USPTO.gov, https://www.uspto.gov/trademarks/laws/updated-trademark-ttab-fees-processes (last visited May 17, 2025).

133 *Summary of 2025 Trademark Fee Changes*, *supra* note 128.

134 Beebe & Fromer, *supra* note 12, at 1030.

later. Therefore, adjusting the maintenance/renewal fees is more effective than adjusting the registration fee as a policy lever.

D. Greater Tolerance for the Co-Existence of Similar/Identical Colors

To reduce color concentration and depletion, the author also suggests that the tests and standards applied in evaluating potentially conflicting color marks should be changed to allow more similar colors to co-exist together. This suggestion is directed not only to the USPTO but also to the courts and legislatures. A higher tolerance for co-existence of similar colors will practically enlarge the available color space in the concentrated areas and reduce entry barriers for new entrants.

1. Reducing the Color Distance for Co-Existence

Currently, the USPTO has a low tolerance for similar colors on the register, giving a broad scope of protection to single-color registrations. Table 4 illustrates some colors that the USPTO regards as being confusingly similar and which therefore cannot co-exist as registrations.[135] One can see that the colors in Pairs 2, 3, 6, 7, and 8 appear very different and therefore should be unlikely to confuse consumers even in a real market setting. But these paired colors have been found to be confusingly similar by the USPTO, and an application to register the latter color has been rejected.[136] Not allowing these distinguishable colors to co-exist causes each color trademark to occupy too much room, limiting the availability of distinct color options. To efficiently use the color space and reduce color concentration/depletion, the USPTO might raise the tolerance of similar colors, to allow more similar single-color trademark registrations to co-exist on the registry.

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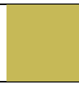
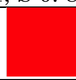
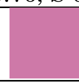
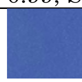
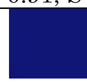
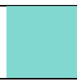
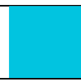
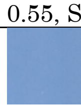
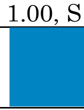
[135] These color pairs are obtained from USPTO office actions in which a USPTO Examining Attorney rejected a later application to register a mark based on the ground that the later mark is considered confusingly similar to the mark an earlier filing. Those rejected applications are U.S. Trademark Application Serial Nos. 88288570, 8684147, 85149118, 78937340, 85684740, 86593915, 87009034, and 77279314.

[136] *See* U.S. Trademark Application Serial Nos. 8684147, 85149118, 86593915, 87009034, and 77279314.

Table 4. Examples of USPTO Judgment on Similar Marks

	USPTO judgement on similar marks	
	Earlier marks	Later marks
Pair 1		
Distance	H 170, B 0.44, S 0.55	H 145, B 0.63, S 0.98
Pair 2		
Distance	H 56, B 1, S 0. 80	H 53, B 0.76, S 0.63
Pair 3		
Distance	H 358, B 0.99, S 0.98	H 326, B 0.91, S 0.42
Pair 4		
Distance	H 222, B0.67, S0.58	H 236, B 0.46, S0.86
Pair 5		
Distance	H174, B 0.85, S 0.40	H 188, B 0.88, S 1.00
Pair 6		
Distance	H 198, B 0.92, S0.74	H185, B 0.36, S0.81
Pair 7		
Distance	H 105, B 0.55, S 0.54	H 120, B 1.00, S 1.00
Pair 8		
Distance	H215, B 0.80, S0.41	H 199, B 0.76, S1.00

Of course, shrinking the allowable distance between two single-color trademarks might increase the likelihood of consumer confusion and therefore the search cost—the time and resources consumers might spend on identifying a specific brand. However, there are several reasons justifying shrinking this color distance. First, trademark law is not about eliminating all consumer confusion. A healthy trademark system should strike a balance between lowering consumer confusion and avoiding anti-competitive effects. In the context of color concentration and depletion, we might tolerate a low level of confusion for an efficient usage of color space, rather than shutting the door to entrants in order to achieve zero confusion. Second, consumers can tolerate certain amounts of confusion and share the cost. Consumers' capacity to distinguish between brands can be shaped by commercial practice. Realizing that color brands have become closer, consumers will naturally increase their attention to avoid confusion in some cases. And this might take them only extra seconds to look at the word mark or logo and recognize a distinction between otherwise similar single-color trademarks, which is not a substantial time investment to individual consumers. Therefore, consumers are less expensive confusion avoiders, compared with the costs that entrants might pay to avoid confusion, including re-designing the color contexts or settling for other "inferior" colors, etc.

This does not mean that an unlimited tolerance for consumer confusion should exist. Those colors that are very similar or identical and lead to unacceptably high levels of confusion should not co-exist. Future empirical research might explore what color distance and what level of consumer confusion are reasonable.

2. Different Legal Standards for Color Conflicts

In addition to allowing coexistence with reduced color distance, the USPTO, legislatures, and courts might also apply different legal standards in trademark infringement and other conflicts between different claimants to single-color trademarks.

a. Dilution on Dissimilar or Unrelated Goods/Services

U.S. dilution law extends the protection scope that an earlier famous trademark enjoys beyond just related or similar goods/services. Thus, dilution law might worsen color depletion because, an earlier, famous single-color trademark filing might block a later-filed single-color trademark application on dissimilar goods or services. Despite the broad scope of protection afforded by dilution law, the plaintiff's burden of proof in a dilution case—once the plaintiff establishes that the mark is famous—is relatively light: the Trademark Dilution Revision Act of 2006 ("TDRA") requires only that the plaintiff prove a likelihood of dilution instead of actual dilution.[137] This lower threshold for proving dilution could result in over-blocking others' trademarks. In practice, large brand owners can exploit dilution laws to intimidate small businesses in unrelated industries.[138] Large companies do not necessarily need to file

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[137] 15 U.S.C. § 1125(c)(2)(B).

[138] Take T-Mobile as an example. T-Mobile threatened to sue small companies in non-related sectors including OXY (a watch maker), Engadget (a news blog), DataJar (a British software company), Compello (an invoice service provider), Slam FM (a Netherland radio station), etc. *See* Timothy Geigner, *Telekom Gets Smartwatch Maker To Change All Its Logos Because Magenta*, Techdirt (Dec. 18, 2015, 6:26 PM), https://www.techdirt.com/2015/12/18/telekom-gets-smart-watch-maker-to-change-all-logos-because-magenta/; Digital Media Law Project, *T-Mobile v. Engadget*, Berkman Center for Internet and Society (April 3, 2008, 12:21 PM), https://www.dmlp.org/threats/t-mobile-v-engadget#node-legal-threat-full-group-description; *T-Mobile Owner Battles DataJAR over Magenta Logo*, BBC (May 14, 2018), https://www.bbc.co.uk/

lawsuits, either; a cease-and-desist letter alone can scare off many small businesses and allow incumbents to claim a large color area expanding across non-related industries that they might never engage with.[139]

This author suggests that the appropriate standard for single-color marks should require a plaintiff to prove actual dilution rather than a likelihood of dilution. Actual dilution should be proven by substantial evidence of the damage to the distinctiveness or good reputation of the plaintiff's mark. For example, the plaintiff could demonstrate dilution by tarnishment by providing survey evidence or witness testimony to prove that, after exposure to a defendant's color mark, some consumers start to perceive goods or services identified by the plaintiff's color trademark as having reduced quality or negative connotations. The evidence should be examined on its validity and objectiveness, dilution arguments should not succeed if the plaintiff does not provide such evidence of actual dilution.

b. Consumer Confusion on Similar or Related Goods/Services

In non-dilution cases where two parties' goods or services are similar or related, additional consideration or weight should be given to the context of the two parties' color usages. If the contexts of the two parties' colors are different enough to avoid consumer confusion, the court should allow the defendant's usage of the color. For example, in *Louboutin*, the plaintiff's red color was used on the outsole contrasting with the upper part of the shoes, while the defendant's red color was used on the entire shoe.[140] The different context and contour of the color was sufficient to distinguish the sources and prevent consumer confusion. In this situation, the court refused to enjoin the defendant's usage of the same color.[141] This ruling is reasonable because it protects the plaintiff's trademark right and allows the defendant to compete by using the same color in a different manner. The decision enabled efficient usage of the concentrated red hue segment by allowing the co-existence of the same color in different contexts.

Lastly, even if the two parties' goods or services are similar and the context of the color use is not by itself sufficient to avoid a likelihood of consumer confusion, additional factors should be

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news/uk-england-sussex-44107621; *T-Mobile Claims Exclusive Rights to Color Magenta*, nu.nl (Nov. 1, 2007 4:27 PM), https://www.nu.nl/economie/1297382/t-mobile-claimt-alleenrecht-op-kleur-magenta.html.

139 Emma Perot, Commercialising Celebrity Persona: Intellectual Property Law and Practice 129, 144–45 (1st ed. 2017).

140 Christian Louboutin S.A. v. Yves Saint Laurent Am. Holding, Inc., 696 F.3d 206, 225 (2d Cir. 2012).

141 *Id.* at 228–29.

considered before prohibiting use of the defendant's color mark. In particular, the court should consider both the consequence of consumer confusion and the existing color concentration and depletion level in the disputed sector. The existing color concentration and depletion level can be captured through the USPTO's adoption of regular monitoring, as suggested in Section VI.A. If the color concentration and depletion level is already high in the disputed sector, the court might consider allowing the parties to coexist since few if any color alternatives remain free and available for use. For example, in *T-Mobile v. Aio*, the co-existence of the parties' colors might initially lead to a few consumer confusions due to the similar services and color context.[142] In this situation, however, the court should further examine whether color concentration and depletion is substantial in connection with telecommunication services given that "all 'primary and secondary colors (red, yellow, blue, green, orange) except violet are owned in the prepaid/wireless space.'"[143] If yes, the court might consider allowing the defendant's usage of the plum color, provided that consumer confusion remains at a low level in an industry with concentrated and depleted color spaces. As explained previously, consumers' capacity to distinguish between brands can increase when realizing that color brands have become closer: they will raise their attention to avoid confusion, which only takes extra seconds. And therefore, such co-existence does not necessarily lead to significant consumer confusion.

E. Reflection on the Fundamental Justification of Trademark Law

In addition to proposing strategies to reduce color concentration and depletion, the research also offers new insights to reflect on the fundamental justification of trademark law. According to mainstream law and economics theory, trademark rights granted on any symbol entail both cost and benefit.[144] The benefit is generated because a trademark helps consumers to identify the desired products quickly and therefore reduces consumer search cost.[145] And the cost stems from the loss of a symbol, which is valuable in economizing product information, from the public domain.[146]

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142 T-Mobile US, Inc. v. Aio Wireless LLC, 991 F. Supp. 2d 888, 926 (S.D. Tex. 2014).

143 *T-Mobile*, 991 F. Supp. 2d at 901.

144 William M. Landes & Richard A. Posner, *The Economics of Trademark Law*, in The Economic Structure of Intellectual Property Law 166, 166-174 (2003); Carter, *supra* note 17; Nicholas S. Economides, *The Economics of Trademarks*, 78 Trademark Rep. 523, 526, 537 (1988).

145 Carter, *supra* note 17, at 762; Landes & Posner, *supra* note 144; Economides, *supra* note 144, at 526.

146 Carter, *supra* note 17, at 770-75.

It is believed that in most cases, the benefit (the reduction of search cost) is greater than the cost (the loss of a symbol) and trademark right granted on a symbol is justified.[147] This is because no matter the actual reduction of search cost, the cost is deemed as zero in most cases.[148] The absence of cost is based on the assumption that there are infinite and equally good symbols in the public domain.[149] If this assumption was true, it would mean the substitutability of symbols would be high, and the loss of any one symbol would not cost the public domain very much.[150] In other words, if all symbols are more or less equally good, an entrant will spend no more costs than an incumbent in developing a trademark by choosing another equally good symbol. Therefore, the cost of removing a symbol from public domain is considered as zero.[151]

Consequently, trademark law is justified by this inequality: the reduction of search cost > the cost of losing a symbol.[152] Courts also note this assumption in trademark infringement cases, emphasizing that it is easy for entrants (defendants) to find and adopt another equally good symbol and turn it into a trademark.[153]

However, the assumption of equally good symbols bears little resemblance to reality. Carter pointed out that if symbols were equally good that we would not see brand owners taking part "in the selection and testing of marks."[154] On the contrary, firms are very serious about selecting and testing marks. Psychological and marketing research explained in Section II also implies some colors are preferred to other colors in branding. Beebe and Fromer have provided empirical evidence that not all single words are equally good, and serious congestion exists for one-syllable word marks.[155] The finding of color concentration in this article further challenges the assumption that all single colors are equally good as marks. If not every word, color, or other symbol is equally good as a

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147 Landes & Posner, *supra* note 144, at 173; Economides, *supra* note 144, at 537–38.

148 Carter, *supra* note 17, at 769. These situations do not include generic or descriptive words as trademarks because these words are considered to be more efficient information economizers than fanciful words such as "Exxon" or "Kodak." Therefore, the cost of using a generic or descriptive word as a trademark would be substantial as the public domain loses an efficient information economizer for which other words cannot substitute. *See* Landes & Posner, *supra* note 144, at 173. Economides, *supra* note 144, at 538.

149 Economides, *supra* note 144, at 537-538; Landes & Posner, *supra* note 144, at 172; Frank I. Schechter, *The Rational Basis of Trademark Protection*, 40 Harv. L. Rev. 813, 833 (1927)

150 Landes & Posner, *supra* note 144, at 172.

151 Carter, *supra* note 17, at 769-770.

152 Carter, *supra* note 17, at 787.

153 Lettuce Entertain You Enters., Inc. v. Leila Sophia AR, LLC, 703 F. Supp. 2d 777, 791 (N.D. Ill. 2010); Aveda Corp. v. Evita Mktg., Inc., 706 F. Supp. 1419, 1429 (D. Minn. 1989); Stork Rest., Inc. v. Sahati, 166 F.2d 348, 361 (9th Cir. 1948).

154 Carter, *supra* note 17, at 770.

155 Beebe & Fromer, *supra* note 12, at 988.

trademark, we should not regard the cost of losing a symbol, such as a color, as zero.

The assumption that there is an unlimited supply of equally good symbols might have seemed true when the trademark registration system was developed—at that time, the number of trademarks in use was relatively small and therefore the universe of available symbols seemed to be nearly infinite. With the rise of branding and marketing, however, millions of symbols have been used and registered in different jurisdictions.[156] The assumption of unlimited symbols is thus no longer realistic. The finding of this article and Beebe & Fromer's findings on word mark depletion reveal a gradually depleting space.[157] As mentioned, the consequence of this trend is not necessarily that we will run out of all existing symbols. Rather, the trend implies that the cost of an ever-shrinking color space will continue to rise and cannot be ignored.

Moreover, the other key assumption underlying trademark law and economics—a reduction of search costs—cannot always be guaranteed in practice. Evidence from the USPTO's Audit program suggests that a significant portion of registered marks in the U.S. are not in use in connection with all of the goods and services in connection with which they are registered,[158] which means many symbols removed from the public domain do not reduce the searching costs because they are not, in fact, in use as trademarks. In addition, as discussed above, so called "trademark bullies" might use their trademark rights to intimidate other companies—especially small businesses—to keep them from using similar trademarks even in markets in which the "bully" does not operate. In such cases, registering a symbol in a concentrated area generates only costs.

The reflection above is not intended to repudiate all trademark rights for single-color or other existing symbols (e.g. single-word marks). Rather, it should inform scholars, policymakers, and judicial practitioners that the assumptions underlying the current trademark law do not always play out in reality. Stakeholders should account for this disconnect between assumption and reality when proposing trademark policies or engaging with trademark matters. The reflection also calls for modifying the unsupported assumption of unlimited, equally good symbols. With more

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[156] From 2013 to 2022, the number of annual trademark applications in many countries doubled or tripled. In the U.S., annual trademark applications rose from 441,059 to 767,237; in China, from 1,878,389 to 7,515,424; in the UK, from 104,212 to 353,820; in India, from 200,392 to 500,250; and in Brazil, from 163,424 to 404,148. *WIPO IP Statistics Data Center*, WIPO (December 2023), https://www3.wipo.int/ipstats/key-search/search-result?type=KEY&key=241.

[157] Beebe and Fromer, *supra* note 12, at 1041.

[158] *Post Registration Audit Program Statistics*, USPTO.gov, *supra* note 109.

empirical evidence provided, future theoretical research might develop a formula for the cost of losing an existing symbol, instead of assuming that claiming a symbol as a trademark has no cost. This research can provide theoretical guidance to policymakers and regulators to identify and reduce the costs in the trademark registration system.

VII. LIMITATIONS AND FUTURE RESEARCH

This research is the first quantitative empirical investigation into color concentration and depletion, making contributions on three key levels. First, the research addresses the gap that existed between the theory of color depletion and supporting empirical evidence. The findings provide quantitative insights into color concentration and depletion across product and service classes. These findings are valuable for trademark scholars in advancing trademark theories and for trademark regulators in understanding potential costs within the trademark registration system. Second, this research is the first to use Python programming to code and analyze color trademark specimens (images) recorded at the USPTO, providing methodological inspiration for other empirical legal researchers who need to process and analyze large volumes of image data for research in various law topics. Last, based on the empirical results, this research proposes specific policy recommendations to the USPTO and courts to mitigate color concentration and depletion.

However, as a first attempt at the quantitative investigation of color concentration and depletion, this research unavoidably has some limitations and flaws. The following paragraphs will discuss some of them and suggest potential directions for future research.

A. Single Color Registered on Non-Related Goods/Services Within the Same Class

As discussed in Section III.A, this research examines color concentration and depletion based on the Nice Classification, assuming that goods/services in the same class are similar or related. However, some goods/services within one class are often unrelated or dissimilar to other goods/services falling within that same class. This means that even within one class, the co-existence of the same or similar single-color trademarks is possible if the goods or services are sufficiently unrelated. Ideally, further analysis would divide each class into groups of related goods or services and assess concentration and depletion within each subgroup just as the USPTO's Trademark Examining Attorneys and judges do today when evaluating the likelihood of confusion for trademarks before them. However, this refined investigation is not practical at this stage. No uniform published standards exist to define the relatedness or similarity between goods/services within one class, as goods/services are evaluated on a case-by-case basis at the USPTO, in the courts, and in the marketplace. Future empirical research could address this gap by coding and analyzing the USPTO and court decisions on good/service similarity in an effort to establish a standard. With such a standard, future research on trademark concentration and depletion could be conducted with greater rigor.

B. The Color Context

As explained previously, the protection scope of single-color trademarks is limited by the context in which the color is used, specifically its design, contour, and location. Consequently, identical or similar colors can coexist if they are applied in distinct designs, contours, or locations. Due to technological limitations, however, this research focuses only on color itself, without considering contextual factors. This approach may overstate the severity of color concentration and depletion, although context alone does not entirely negate the trend of color depletion or concentration.

Future research could incorporate color context into estimations by using image-processing AI technologies. For instance, an AI tool capable of comparing images and grading their similarity could enable more accurate estimations of color depletion and concentration.

C. Black, White, Gray, and Translucent Colors

This research focuses on chromatic colors instead of achromatic ones such as black, white, gray, and translucent. Registering achromatic colors as single-color trademarks is difficult, as they are sometimes considered to be functional in connection with certain goods/services. For example, the color of black flower packaging boxes[159] and black out-board engines[160] have both been held to be aesthetically functional. Nonetheless, depletion and concentration may still occur with these colors, because colors such as black, white, and gray offer limited distinguishable shades. Future empirical research might explore concentration and depletion in these achromatic colors.

D. The Interpretation of Color Depletion and Concentration

This research aims to reveal the status of color concentration and depletion rather than to provide specific interpretations of these phenomena. However, it does not diminish the importance of

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[159] *In re* Florists' Transworld Delivery, Inc., 106 U.S.P.Q.2d 1784, 1790 (T.T.A.B. 2013).

[160] Brunswick Corp. v. British Seagull Ltd., 35 F.3d 1527, 1531 (Fed. Cir. 1994).

interpretation: a deep understanding of the causes behind concentration and depletion is essential for policymakers and regulators to address these issues and develop long-term strategies. Future research could investigate the specific reasons underlying color depletion and concentration, offering greater interpretive insight.

APPENDICES

Appendix 1. Supplemental Assessment of Color Wheel Division Sufficiency

1. The assessment on whether the division of 25-hue spectrum needs to be further divided

In the 25-hue spectrum (Figure A), most segments cover 10 degrees each (e.g., hue 16-25; hue 26-35; hue 36-45, etc.). However, there are five hue segments that cover more than 10 degrees: the red segment (hue 346-15), the green segment (hue 96-155), the dark blue segment (hue 226–255), the magenta segment (hue 296-315), and the plum segment (hue 316-335).

Figure A. The 25-Hue Spectrum

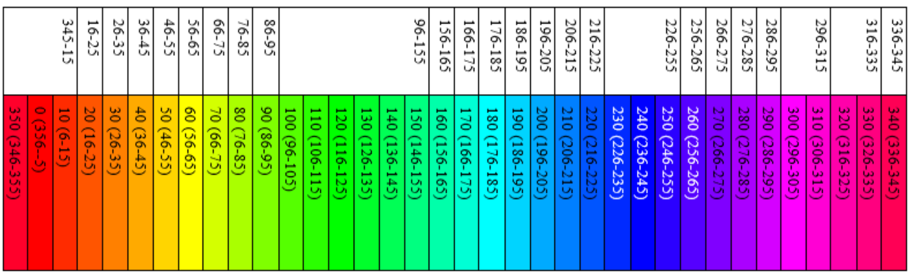


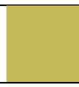
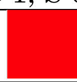
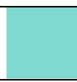
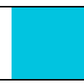
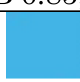
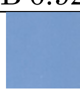
Figure A shows that the subdivision within the green segment (hues 96–155) is unnecessary since the six cells in this segment (hues 96–155) are difficult to distinguish. The same holds true for all of the five hue segments. The differences within these segments are expected to be hardly noticeable in a real market environment, where consumers rarely compare two colors side by side. Instead, they typically encounter one color in a shop or online advertisement and retrieve the corresponding color from their memory. This suggests that the 25-hue division is not under-divided and sufficiently captures the relevant color distinctions for this research. Further divisions within the segments would not yield significant perceptible differences and are therefore unnecessary.

2. The assessment on whether the division of 100-cell color space is sufficient for this research

For this research, the entire color space is divided into 100 independent cells: 25 hue segments multiplied by four shades (varied in saturation and brightness). This 100-cell color space is sufficient for this research, compared with the implicit standards of the USPTO.

Table A below lists seven pairs of colors determined to be confusingly similar in the USPTO's official decisions.[1] The hue, saturation, and brightness values (the HSB codes) are provided under each color. The USPTO has determined that consumers in the market are likely to overlook the difference between the two colors in each pair, and therefore consumer confusion is likely.

Table A

	USPTO Standard for similar marks	
	Earlier marks	Later marks
Pair 1		
Distance	H 170, B 0.44, S 0.55	H 145, B 0.63, S 0.98
Pair 2		
Distance	H 56, B 1, S 0. 80	H 53, B 0.76, S 0.63
Pair 3		
Distance	H 358, B 0.99, S 0.98	H 326, B 0.91, S 0.42
Pair 4		
Distance	H 222, B0.67, S0.58	H 236, B 0.46, S0.86
Pair 5		
	H174, B 0.85, S 0.40	H 188, B 0.88, S 1.00
Pair 6		
	H 198, B 0.92, S0.74	H185, B 0.36, S0.81
Pair 7		
	H215, B 0.80, S0.41	H 199, B 0.76, S1.00

These pairs are then plotted into the 100-cell color space. If the pairs, which the USPTO considers to be non-distinguishable to consumers, fall into different cells in the 100-cell space, it means that the current division is more sensitive and sophisticated than the USPTO standard and therefore is adequate for this research.

1 These color pairs are obtained from USPTO office actions that rejected a later mark based on the ground that it is confusingly similar to an earlier mark. Those refused marks are U.S. Trademark Application Serial Nos. 88288570, 8684147, 85149118, 78937340, 85684740, 86593915, and 77279314.

The plotting includes two steps. For the first step, the pairs are plotted into the 25-hue spectrum regardless of brightness and saturation. If one pair falls into different hue segments in the 25-hue spectrum, the pair definitely falls into different cells in the 100-cell space. If a pair falls into the same hue segment, the colors' saturation and brightness must be checked to see if the pair falls into the same cell in the 100-cell space.

According to the hue values in Table A, all pairs fall into different hue segments. Therefore, all pairs fall into different cells in the 100-cell space, and there is no need to further check the dimensions of saturation and brightness. This plotting indicates that the 100-cell color space is more sophisticated than the USPTO standard and is therefore adequate for this research.

Appendix 2. Python Code for Processing Color Trademark Drawings

```
File  Edit  Format  Run  Options  Window  Help
from sklearn.cluster import KMeans
import matplotlib.pyplot as plt
import numpy as np
import cv2
from collections import Counter
from skimage.color import rgb2lab, deltaE_cie76
import os
from os import listdir
from os.path import isfile, join
import math
import colorsys

def RGB2HEX(color):
    return "#{:02x}{:02x}{:02x}".format(int(color[0]), int(color[1]), int(color[2]))

def get_image(image_path):
    image = cv2.imread(image_path)
    image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
    return image

def modify_image(image):
    modified_image = cv2.resize(image, (600, 400), interpolation = cv2.INTER_AREA)
    modified_image = modified_image.reshape(modified_image.shape[0]*modified_image.shape[1], 3)
    return modified_image

def cluster_image(modified_image,n_clusters):
    clf=KMeans(n_clusters)
    labels=clf.fit_predict(modified_image)
    counts=Counter(labels)
    center_colors=clf.cluster_centers_
    ordered_colors=[center_colors[i] for i in counts.keys()]
    hex_colors=[RGB2HEX(ordered_colors[i]) for i in counts.keys()]
    rgb_colors = [ordered_colors[i] for i in counts.keys()]
    return rgb_colors

path=r'C:
#print(path)
onlyfiles = [f for f in listdir(path)if isfile(join(path, f))]

color_results=dict()
for f in onlyfiles:
    # print(f)
    image=get_image(join(path,f))
    #print(image)
    modified_image=modify_image(image)
    rgb_colors=cluster_image(modified_image,2)
    #print(rgb_colors)
    look=rgb_colors[0]
    is_white=(look[0]>240)and (look[1]>240)and (look[2]>240)
    is_black=(look[0]<30)and (look[1]<30)and (look[2]<30)
    if not (is_white or is_black):
        color_results[f]=rgb_colors[0]
    else:
        color_results[f]=rgb_colors[1]

print(color_results)
#print(hex_colors)
```

untitled

File Edit Format Run Options Window Help

```
import math
import numpy as np
import colorsys

rgbcolors={'86242227ImageAgentProxy(93).jpg': [ 97.17224863, 163.25290676, 103.57327239], '86380410ImageAgentProxy(97).jpg': [ 61.76637229, 201.10027422, 183.42024917], '86596429ImageAgentProxy(92).jpg': [183.5692239 , 204.36034217,  95
'88413448ImageAgentProxy(14).jpg': [ 45.57342657, 132.11074306, 140.22332638], '88470188ImageAgentProxy(26).jpg': [119.47285673, 187.02054688,  35.07773048], '88511539ImageAgentProxy(1).jpg': [ 14.64669721, 171.44549092, 168.84886621],
'88673747ImageAgentProxy(12).jpg': [ 62.08507252, 191.70953171,  63.04289363], '88702848ImageAgentProxy(30).jpg': [ 90.79553862, 145.86350559, 122.1444158 ], '88715955ImageAgentProxy(28).jpg': [105.77039244, 177.85767529,  78.0487613 ],
'85157551ImageAgentProxy(98).jpg': [ 62.3948749 , 167.41075138, 115.3818439 ], '86009787ImageAgentProxy(96).jpg': [ 29.88717092, 238.79133584,  25.45570414], '86018988ImageAgentProxy(12).jpg': [  1.98386383, 152.49526811,  68.36923057],
'77082023ImageAgentProxy(99).jpg': [117.26717804, 155.69423536, 156.87844384], '77174496ImageAgentProxy(98).jpg': [125.58594492, 168.4515443,  92.18244924], '77238419ImageAgentProxy(97).jpg': [ 24.7020876 , 210.22613523,  24.88018754],
'76530855ImageAgentProxy(14).jpg': [ 87.98654161, 167.45147147, 128.18172385], '76623985ImageAgentProxy(10).jpg': [150.92184495, 166.77087341, 152.41059863], '76662868ImageAgentProxy(6).jpg': [54.23412422, 88.80395685, 57.76537649], '76


def convert(dict_rgbcolors):
    dict1=dict() # develop a new dictionary
    for key, value in dict_rgbcolors.items(): # extract r,g,b values from the old dictionary
        r=value[0]
        g=value[1]
        b=value[2]
        hsv=colorsys.rgb_to_hsv(r/255,g/255,b/255)  # make transformation of the old dictionary and creat the new dictionary
        dict1[key]=hsv   # input the new values into the new dictionary
    return dict1  # get the new dictionary

hsv_colors=convert(rgbcolors)   # pass the targeted values into the new dictionary

import openpyxl
from openpyxl import Workbook

# Create the workbook and sheet for Excel
workbookyellow = openpyxl.Workbook()
sheetyellow = workbookyellow.active

# openpyxl does things based on 1 instead of 0
row = 1
for key,values in hsv_colors.items():
    # Put the key in the first column for each key in the dictionary
    sheetyellow.cell(row=row, column=1, value=key)
    column = 2
    for element in values:
        # Put the element in each adjacent column for each element in the tuple
        sheetyellow.cell(row=row, column=column, value=element)
        column += 1
    row += 1

workbookyellow.save(filename="my_workbookgreen-hsv.xlsx") # it is saved at the default place
```

Appendix 3: The Methodology of Estimating Depletion Proportions (Percentages) in Each Product/Service Class

To estimate depletion, the method plots all single-color trademark filings in one class into the 100-cell space and examines how many cells have been taken up. For example, Class 24 has in total five single-color trademark filings (Reg. Nos. 3474557, 3097115, 5056526, and 5338162 and Application Serial No. 88692739).[2] These five trademark filings are plotted into the 100-cell space. The process includes two steps:

Step 1: Plot the five single-color trademark filings into the 25-hue segments. Each dot in Figure B(a) (below) represents a single-color trademark in Class 24. Among the five dots, three fall separately into three hue segments: hues 345–15, 46–55, and 216–225. This means the three dots fall into three separate cells in the 100-cell space. The remaining two dots fall into the same hue segment 196–205, requiring a further check of the two dots' brightness and saturation to identify whether they fall into different shades.

Step 2: Plot the remaining two single-color trademark filings into the four-shade quadrant. Figure B(b) (below) shows the four-shade quadrant (horizontal axis: brightness; vertical axis: saturation). If the two dots fall into the same shade, it means that they are in the same cell in the 100-cell color space, while if they fall into different shades, it means that they are in two different cells. The plotting of the remaining two dots indicates that they are in the same shade area (the area of high brightness and low saturation). It means the two dots fall into the same cell in the 100-cell space.

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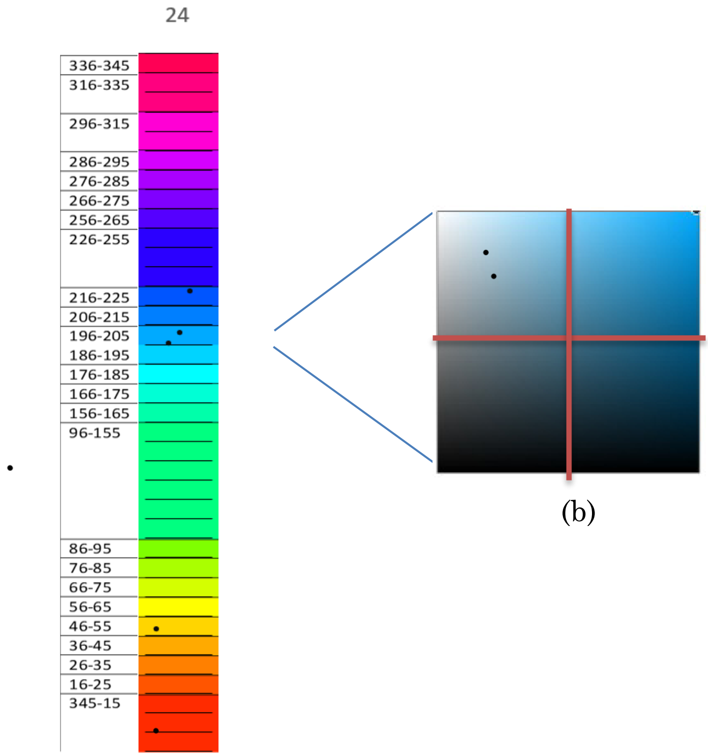
2 The data set was collected at the end of 2019. After 2019, the status of some trademarks collected might change. Two single-color trademark filings (Reg. No. 5338162 and Application Serial No.88692739 in Class 24) were cancelled or abandoned after 2019. We still keep them in the analysis, as it is not practical to re-check the large volume of trademark filing one by one given that the status of trademark filings changes every day. And the status change after 2019 should not influence the validity of the data collected between 2003 and 2019 in this research. In addition, the trademark filing under Reg. No. 5338162 is labeled as a word mark, but the applicant also claimed "Red or pink (single color used for the entire goods/services)" under the single-color trademark code 29.02.01. As a result, the research considers this situation to be a single-color trademark based upon this applicant's claim and the design code used.

Figure B



(a) (b)

To sum up, the five dots in Class 24 fall into four separate color cells: the first three fall into three cells and the remaining two fall into one cell. So, the 100-cell color space has **four cells being taken up by single-color trademarks in Class 24, which means the color space has 4% depletion in this class**. Through this method of plotting and calculation, the depletion in each product/service class can be estimated.

Appendix 4: The Methodology of Estimating Depletion Speed

The methodology includes three steps:

Step 1: Calculate the depletion percentage in each year in one good/service class.

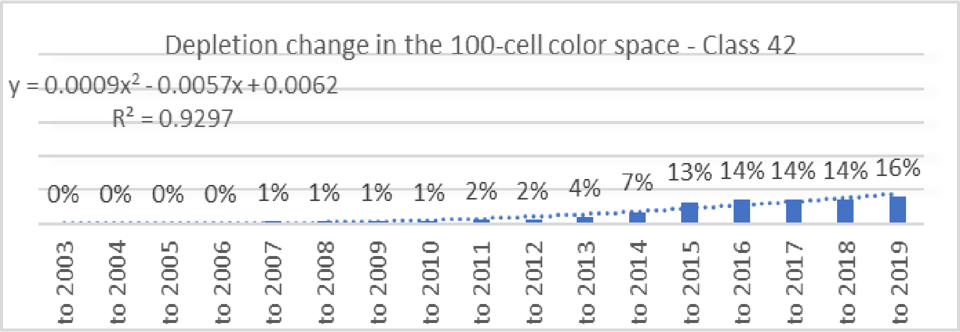
The calculation is the same as the method in Appendix 3 except that the depletion percentage is calculated for each year. The depletion percentage for each year counts both the new single-color trademark filings that year and those filed in previous years that are still alive in that year. For example, the depletion percentage of 2005 counts both the single-color trademarks filed in 2005 and those filed before 2005 that are still alive in 2005.

Step 2: Plot the depletion percentage for each year in one good/service class in the column chart and develop the mathematic function of the historical trend of depletion.

Figure C (below) plots the depletion percentages from 2003 to 2019 in Class 42. The horizontal axis (x) denotes the year: 2003 is year 1 (x=1), 2004 is year 2 (x=2), 2019 is year 17 (x=17). The vertical axis (y) denotes the depletion percentage.

Based on the depletion percentage for each year, a mathematic function revealing the depletion percentage in response to the year is developed: y= $0.0009x^2$ -0,0057x+0.0062.[3]

Figure C

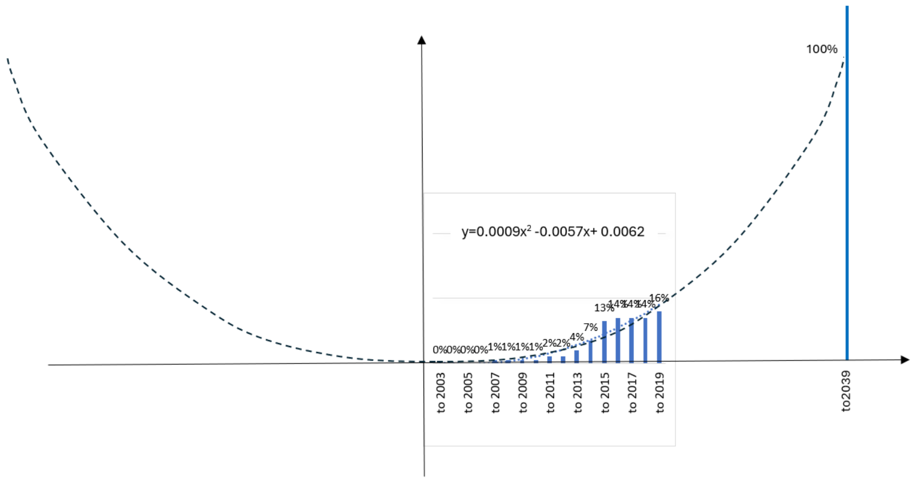


3 This mathematic function is generated using Microsoft's Excel spreadsheet software, which can generate optional functions and curves such as linear, polynomial, logarithm, etc. from the data. Each available function was applied to each plot of depletion versus time, and the function providing the highest R^2 (coefficient of determination) value was selected. The higher the R^2 value, the better fit of the function to the data.

Step 3: Predict the year when the depletion percentage is 100% (all 100 cells are claimed by trademarks).

With the mathematic function developed in Step 2, one can calculate the corresponding year for a full depletion percentage, namely y = 100% (Figure D, below). The method is straightforward: calculating the x value, given y =1 (100%).[4]

Figure D



With this method (Steps 1–3), one can estimate the time when full depletion will occur in each of the 45 classes of goods and services. The schedule of all 45 classes is shown in Figure 15 in the main body of this article.

4 For the function y = 0.0009x² - 0,0057x + 0.0062, given y = 1, x = 37. It means 100% depletion (y = 1) happens when x = 37, namely 2039 (= 2003 + 37 - 1).

Appendix 5: The Mathematic Functions and Curves of the Annual Depletion Percentages Across 45 Classes

Chart 1. Depletion change in the 100-cell color space— Class 1. Peak point: x= 16.2857, y = 0.1451.

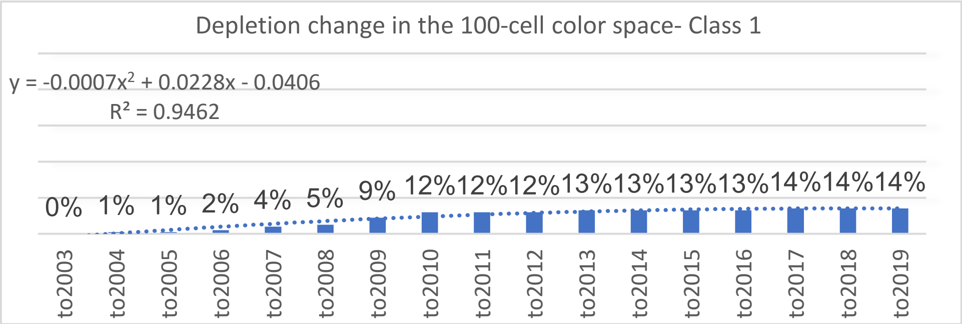


Chart 2. Depletion change in the 100-cell color space— Class 2. Peak point: x = 27, y = 0.0636.

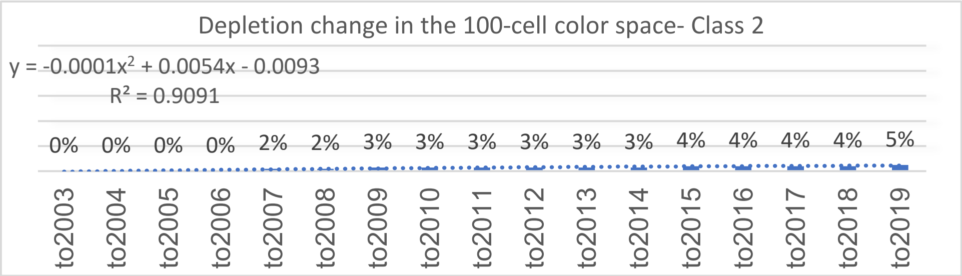


Chart 3. Depletion change in the 100-cell color space— Class 3. Given y = 1, x = 71.7733.

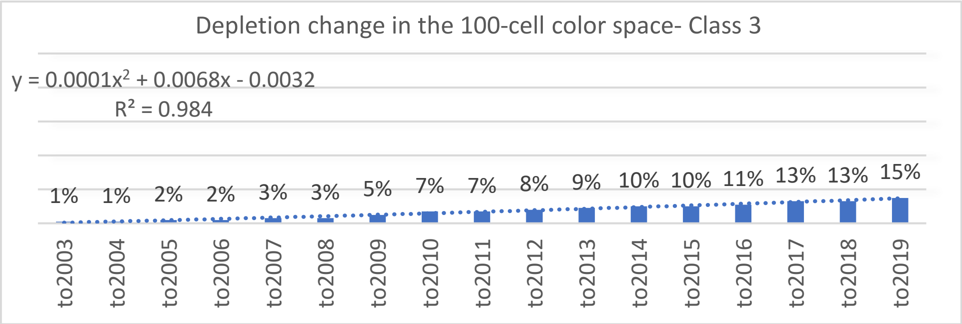


Chart 4. Depletion change in the 100-cell color space—Class 4. Peak point: y = 0.0438, x = 21.

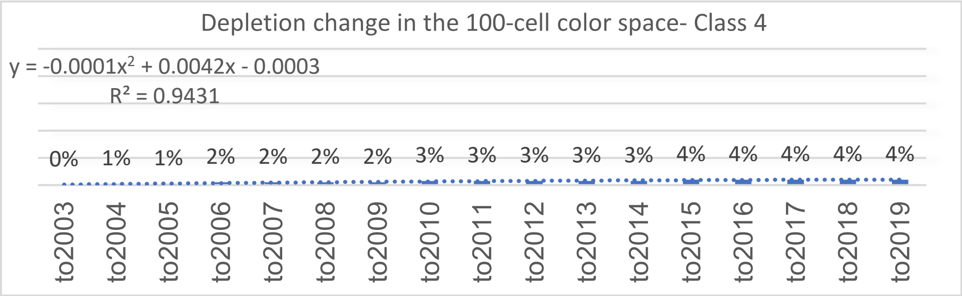


Chart 5. Depletion change in the 100-cell color space—Class 5. Given y = 1, x = 29.9324.

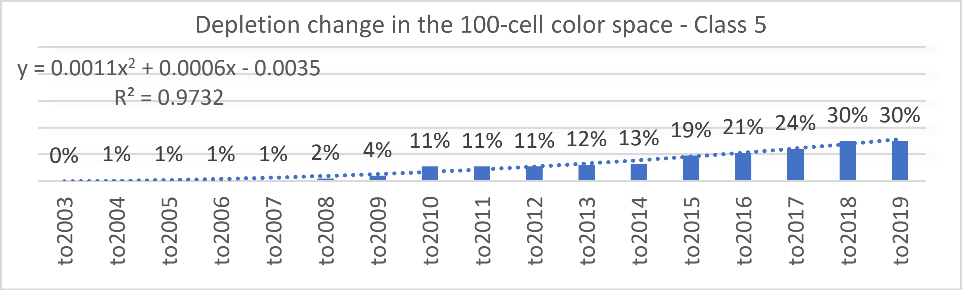


Chart 6. Depletion change in the 100-cell color space—Class 6. The peak point x = 14.85, y = 0.1951.

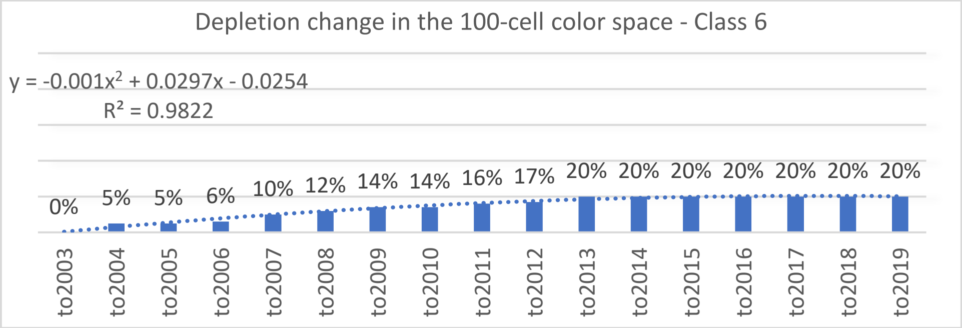


Chart 7. Depletion change in the 100-cell color space— Class 7. Peak point: y = 0.3726, x = 31.375.

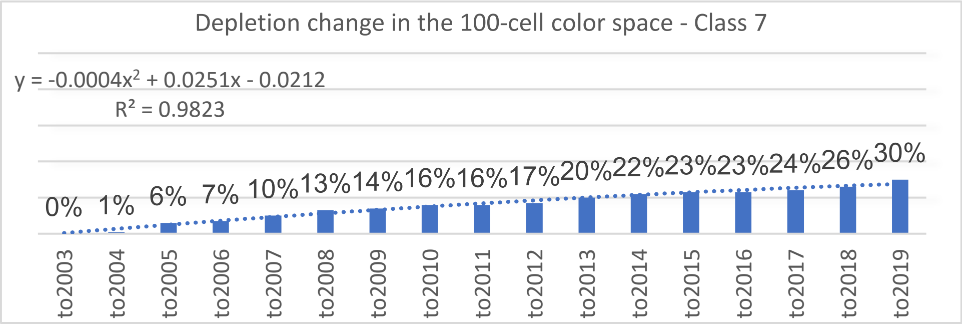


Chart 8. Depletion change in the 100-cell color space— Class 8. Given y = 1, x = 72.3043.

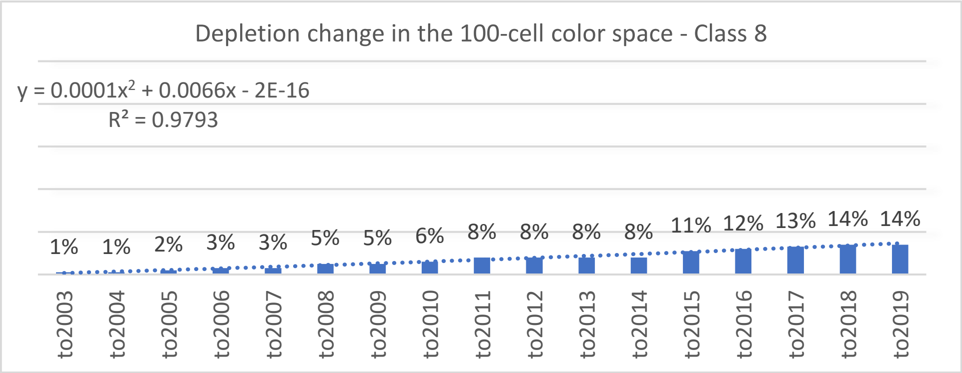


Chart 9. Depletion change in the 100-cell color space— Class 9. Given y = 1, x = 34.2036.

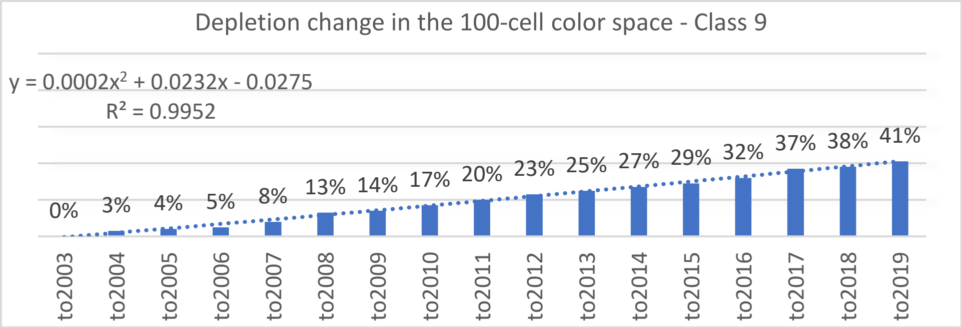


Chart 10. Depletion change in the 100-cell color space—Class 10. Given y = 1, x = 37.0976.

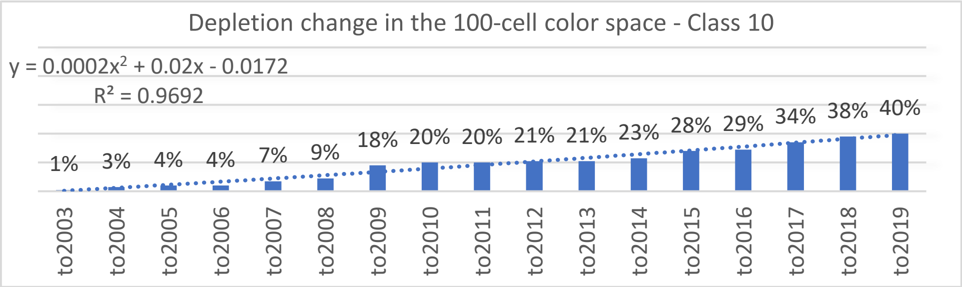


Chart 11. Depletion change in the 100-cell color space—Class 11. Given y = 1, x = 40.4872.

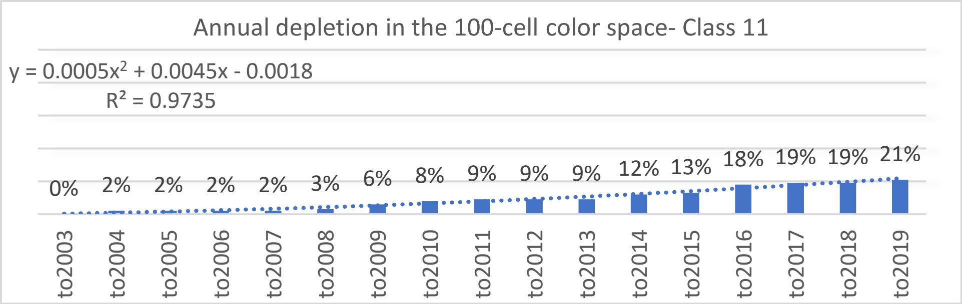


Chart 12. Depletion change in the 100-cell color space—Class 12. Given y = 1, x = 84.1883.

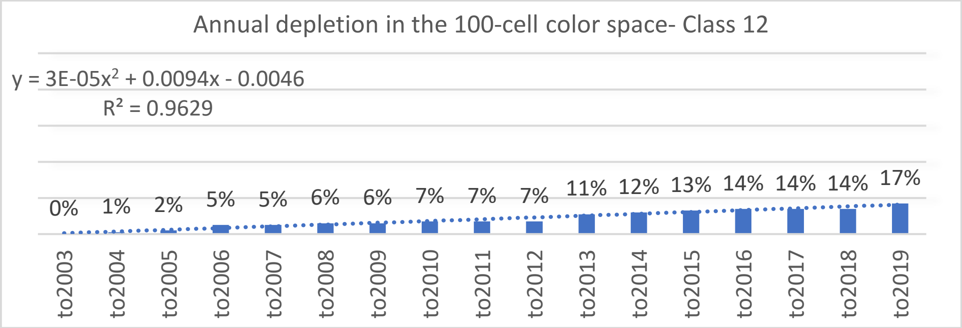


Chart 13. Depletion change in the 100-cell color space—Class 13. Given y = 1, x = 53.7481.

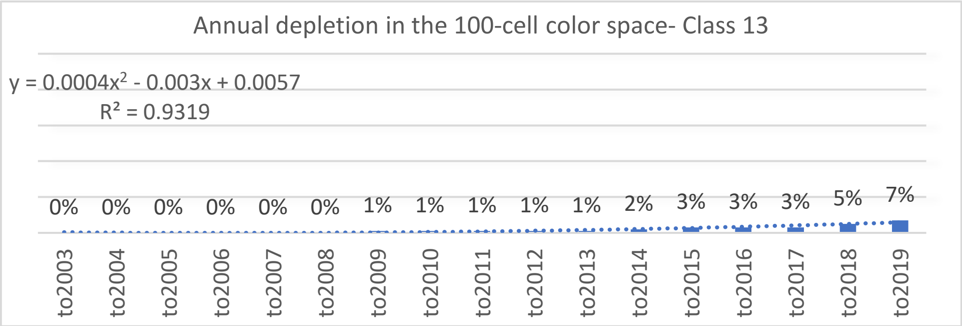


Chart 14. Depletion change in the 100-cell color space—Class 14. Given y = 1, x = 100.7420.

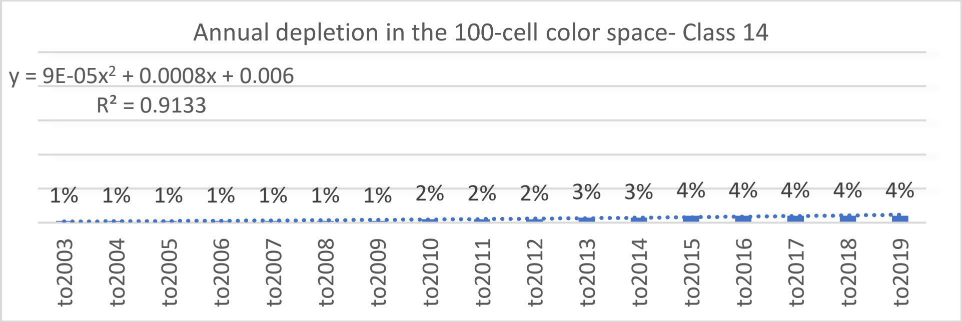


Chart 15. Depletion change in the 100-cell color space—Class 15. Given y = 1, x = 3.2537×10^{58}.

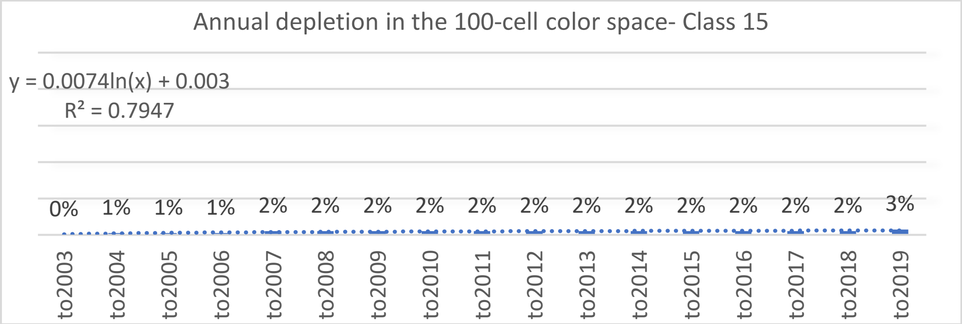


Chart 16. Depletion change in the 100-cell color space—Class 16. Peak value: y = 0.1827; x = 19.25.

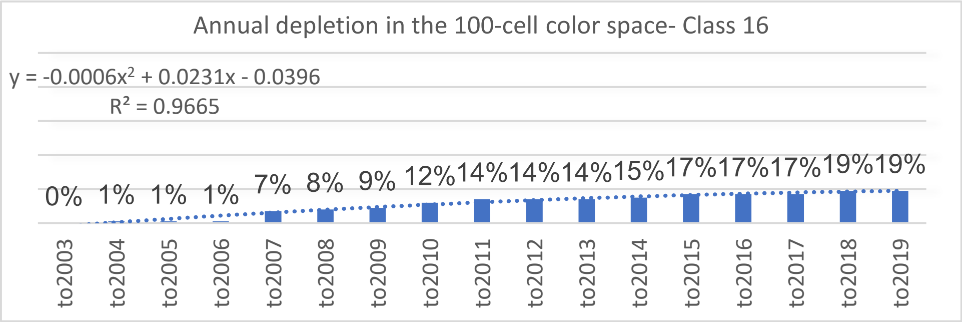


Chart 17. Depletion change in the 100-cell color space—Class 17. The peak point x = 17.85, y = 0.2574.

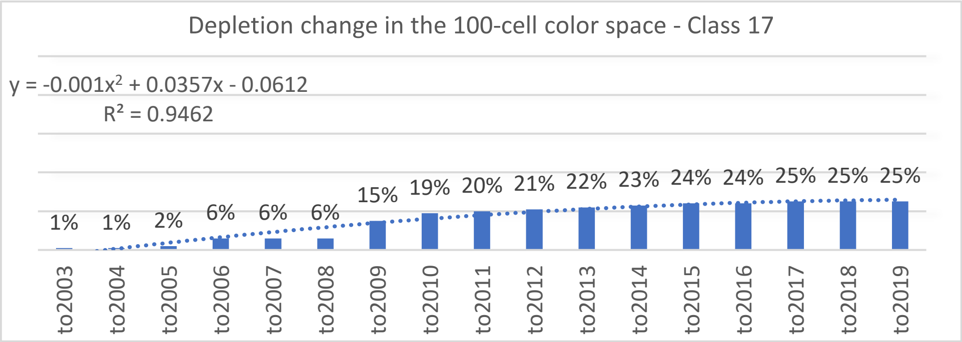


Chart 18. Depletion change in the 100-cell color space—Class 18. Given y =1, x = 69.4137.

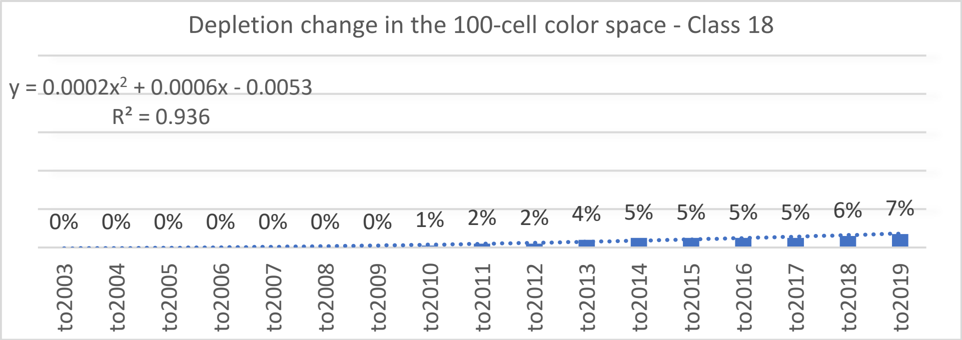


Chart 19. Depletion change in the 100-cell color space—Class 19. The peak point x = 16.9167, y = 0.1542.

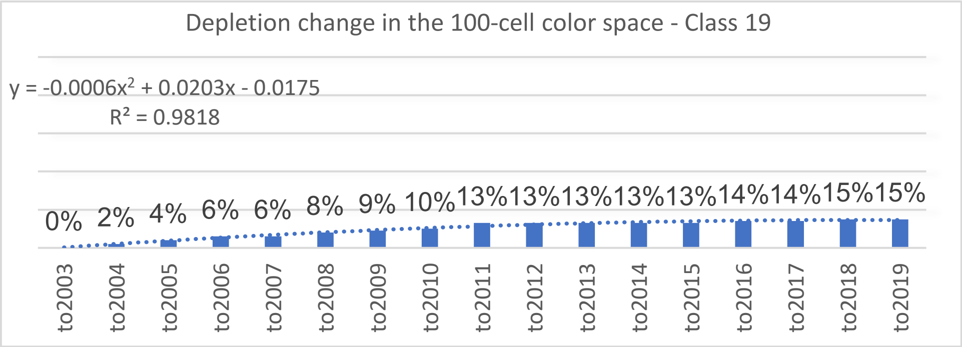


Chart 20. Depletion change in the 100-cell color space—Class 20. Given y = 1, x = 42.9470.

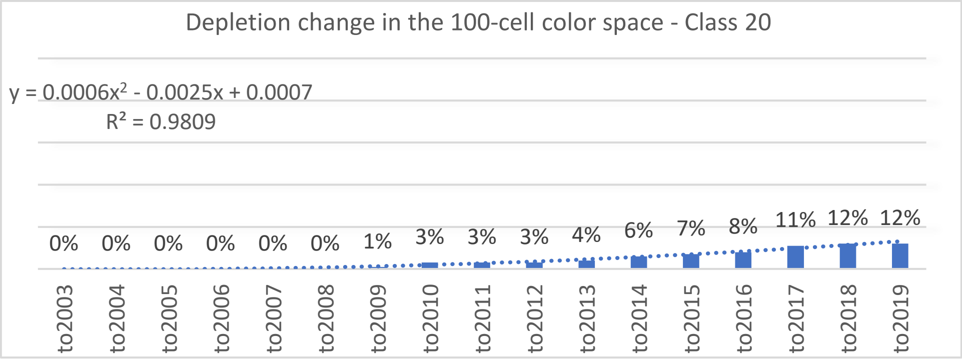


Chart 21. Depletion change in the 100-cell color space—Class 21. Given y = 1, x = 39.1432.

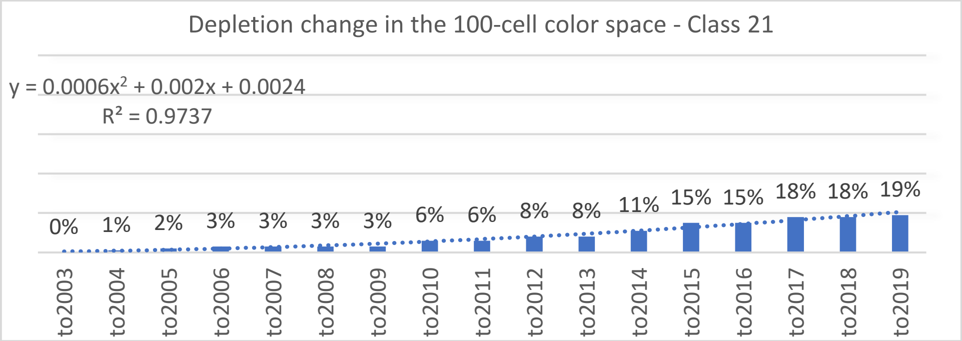


Chart 22. Depletion change in the 100-cell color space—Class 22. Peak point: y = 0.0145; x = 30.

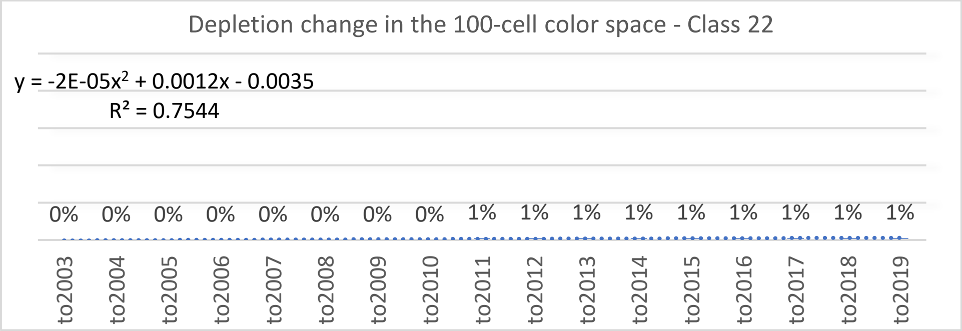


Chart 23. No single-color registrations in Class 23.

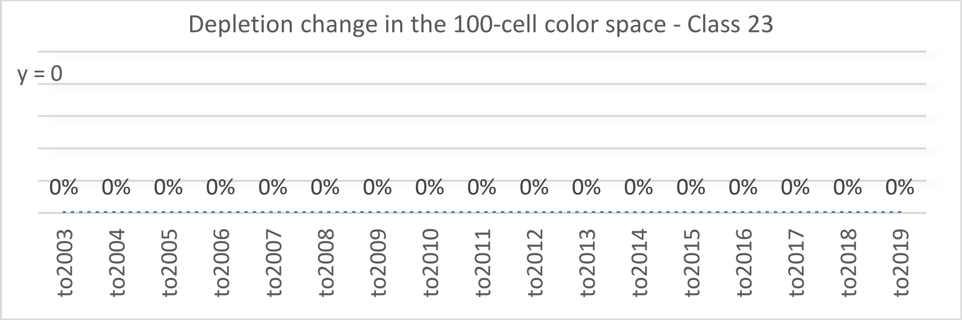


Chart 24. Depletion change in the 100-cell color space—Class 24. Given y = 1, x = 130.3259.

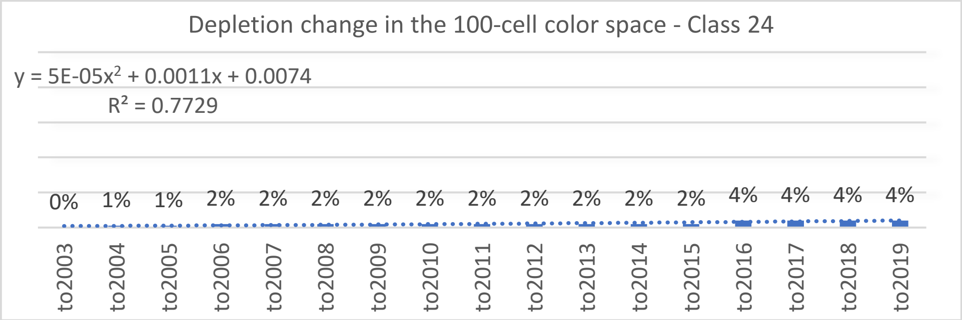


Chart 25. Depletion change in the 100-cell color space—Class 25. Given y =1, x = 42.2471.

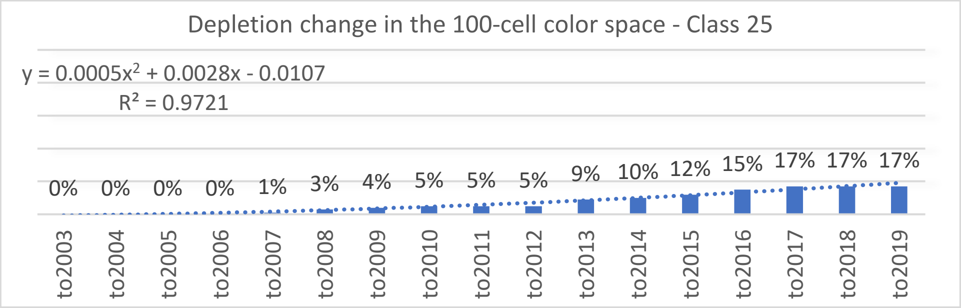


Chart 26. Depletion change in the 100-cell color space—Class 26. Given y = 1, x = 169.9182.

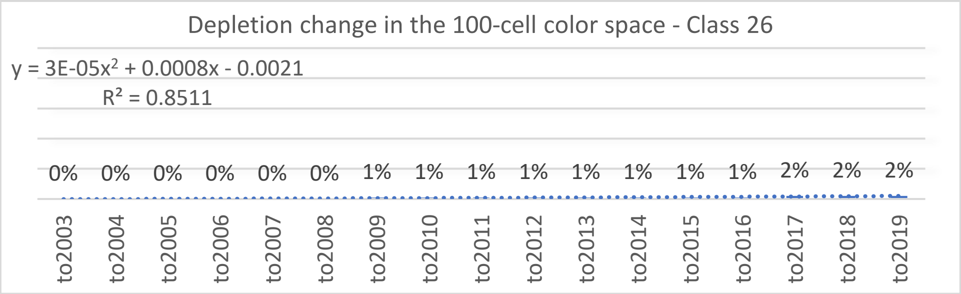


Chart 27. No single-color registrations in Class 27.

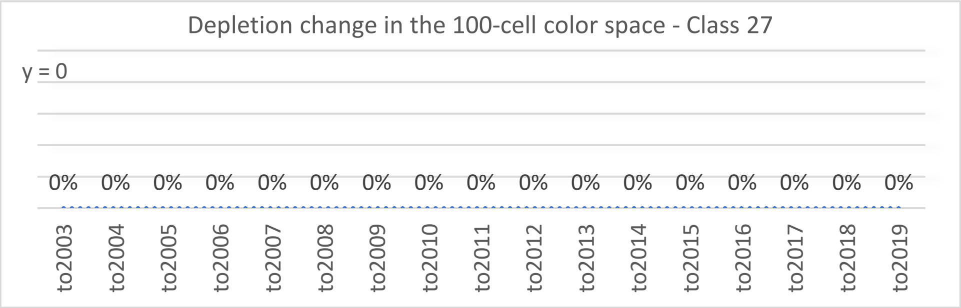


Chart 28. Depletion change in the 100-cell color space— Class 28. Given y=1, x = 74.3184.

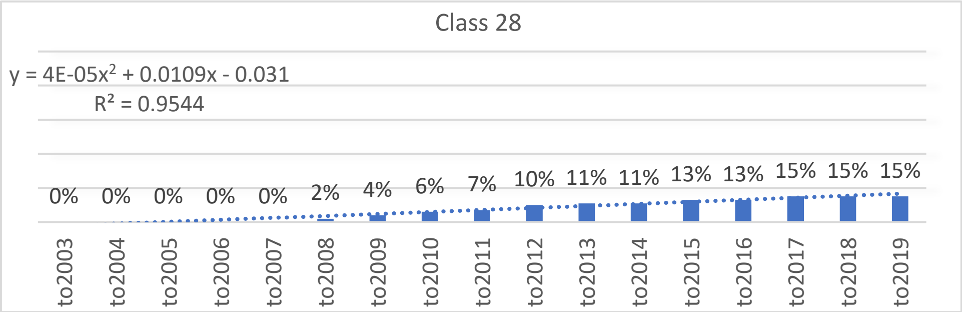


Chart 29 Depletion change in the 100-cell color space— Class 29. Given y=1, x = 160.5525.

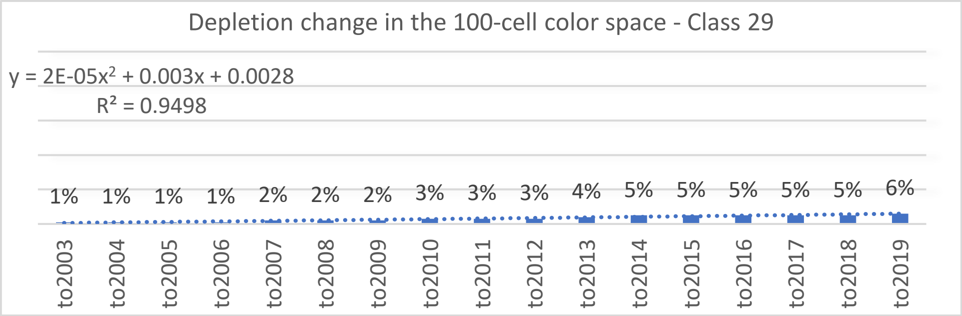


Chart 30. Depletion change in the 100-cell color space— Class 30. Given y = 1, x = 51.7124.

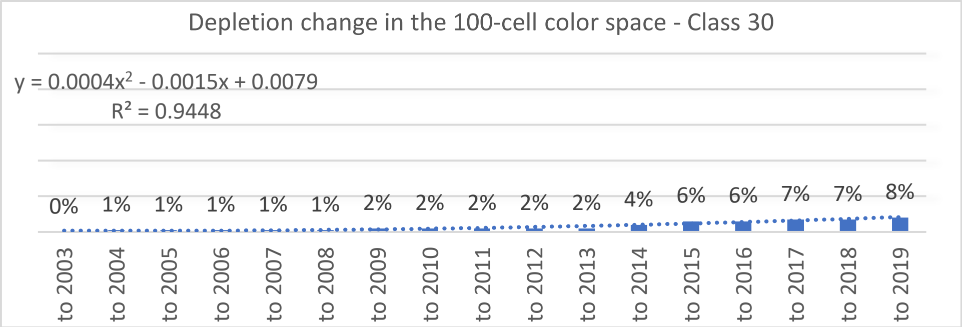


Chart 31. Depletion change in the 100-cell color space—Class 31. Given y = 1, x = 64.1367.

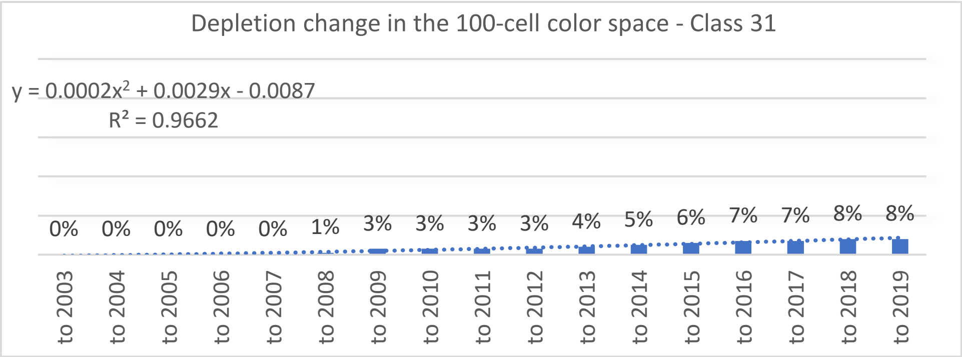


Chart 32. Depletion change in the 100-cell color space—Class 32. Given y = 1, x = 72.7036.

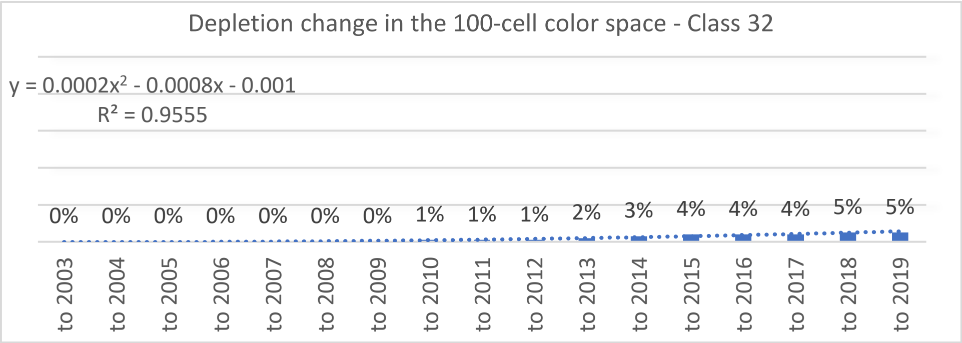


Chart 33. Depletion change in the 100-cell color space—Class 33. Peak point: x = 65.5, y = 0.402725.

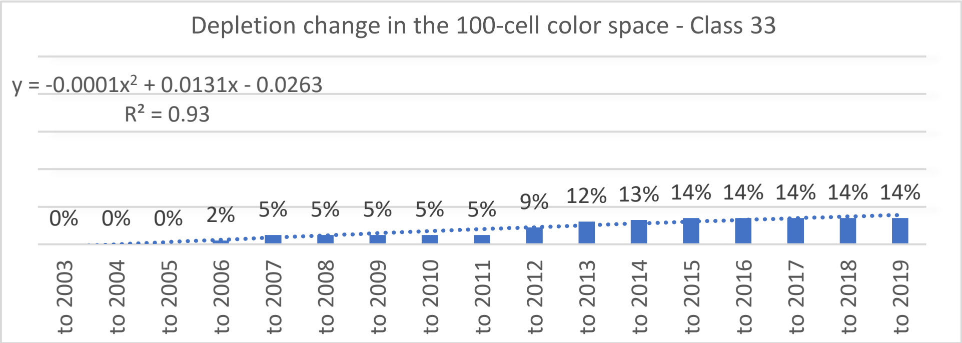


Chart 34. Depletion change in the 100-cell color space—Class 34. Given y = 1, x = 140.8515.

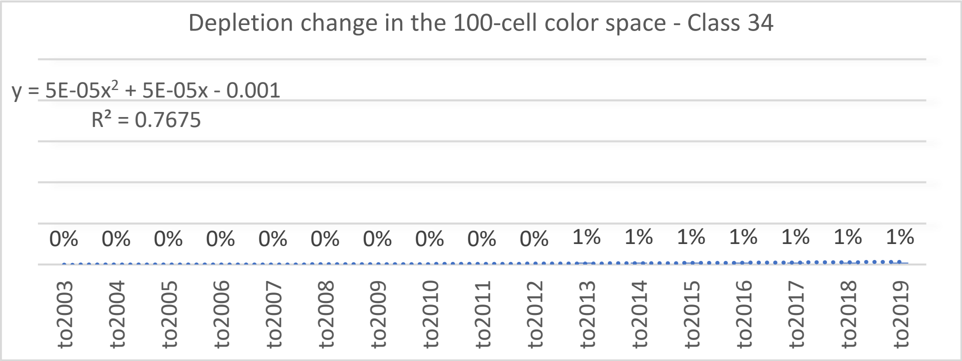


Chart 35. Depletion change in the 100-cell color space—Class 35. Given y =1, x = 40.4009.

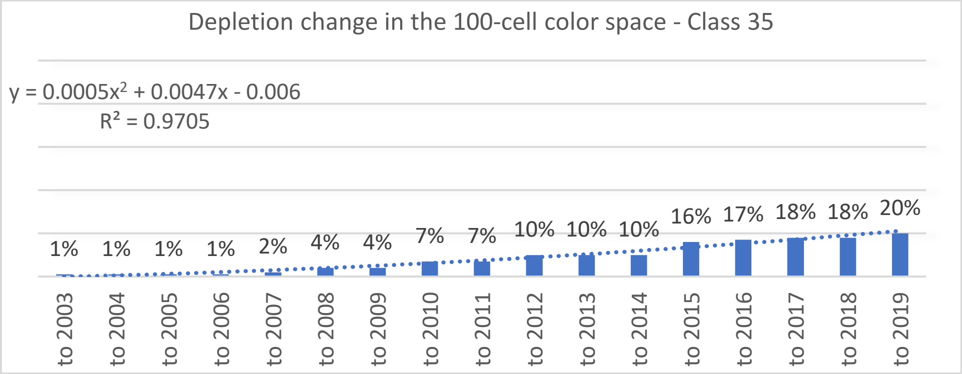


Chart 36. Depletion change in the 100-cell color space—Class 36. Given y = 1, x = 44.4425.

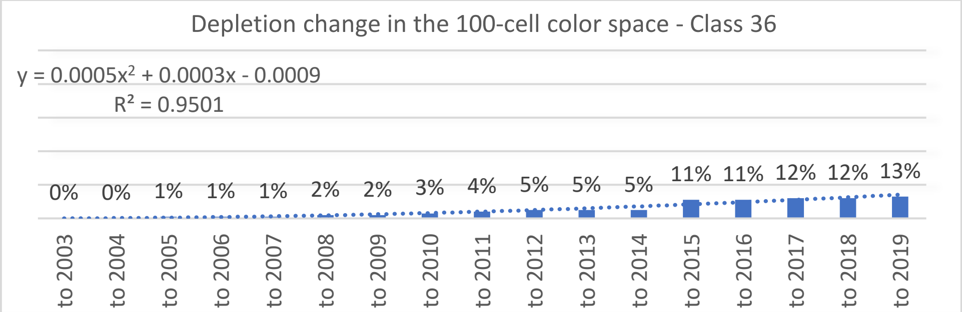


Chart 37. Depletion change in the 100-cell color space—Class 37. Peak point: y = 0.5031, x= 85.7143.

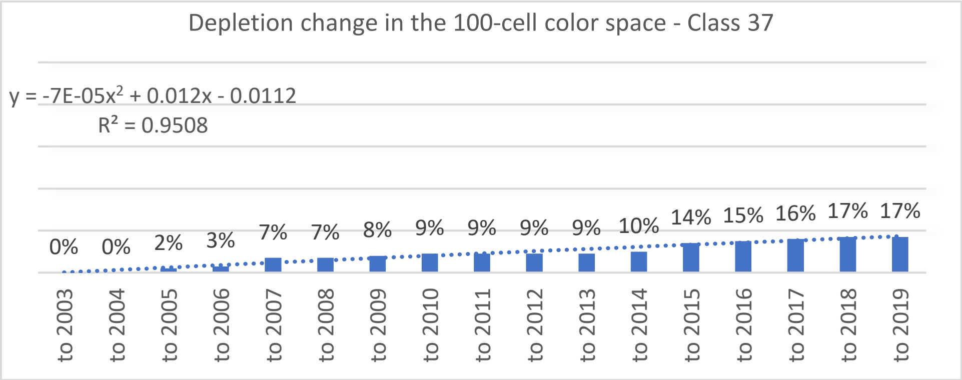


Chart 38. Depletion change in the 100-cell color space—Class 38. Peak point: y = 0.1637; x = 43.

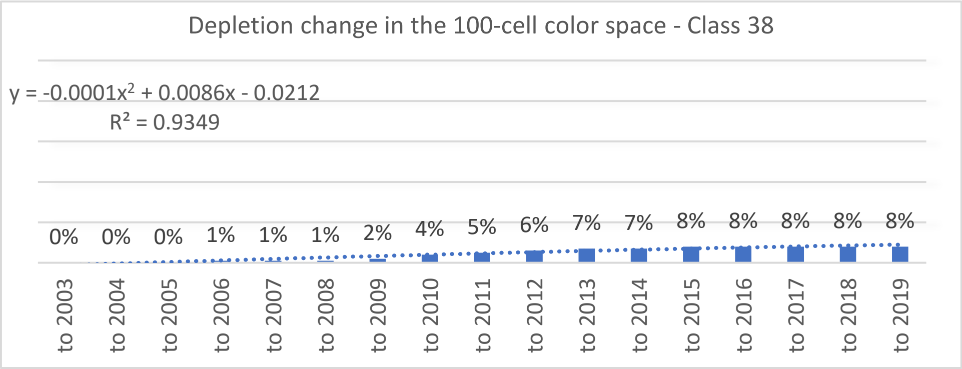


Chart 39. Depletion change in the 100-cell color space—Class 39. Given y = 1, x = 47.9190.

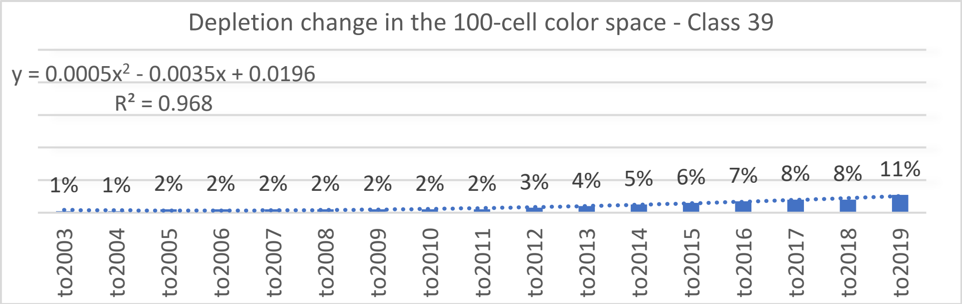


Chart 40. Depletion change in the 100-cell color space—Class 40. Given y = 1, x = 127.4177.

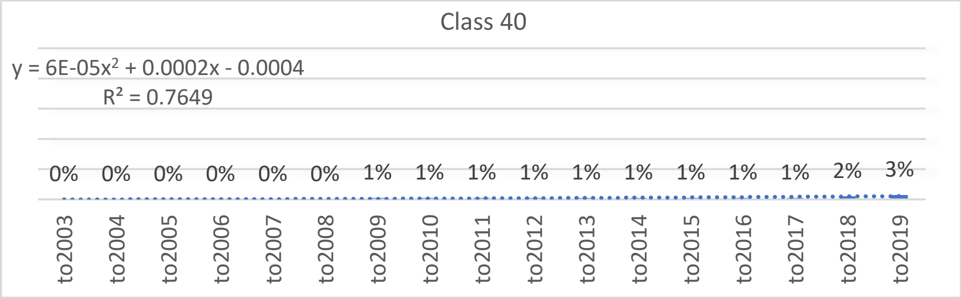


Chart 41. Depletion change in the 100-cell color space—Class 41. Given y = 1, x = 47.1228.

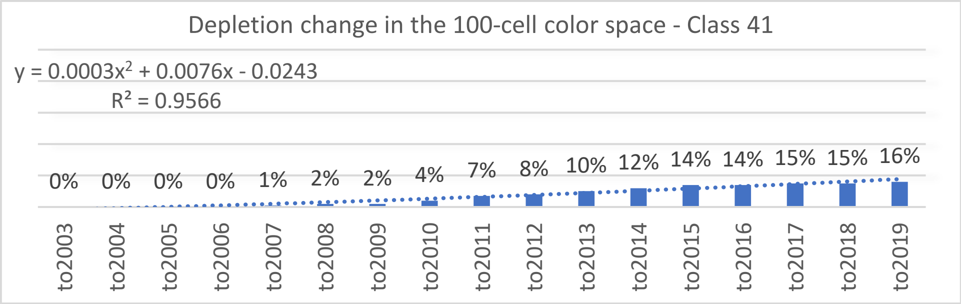


Chart 42. Depletion change in the 100-cell color space—Class 42. Given y = 1, x = 36.5471.

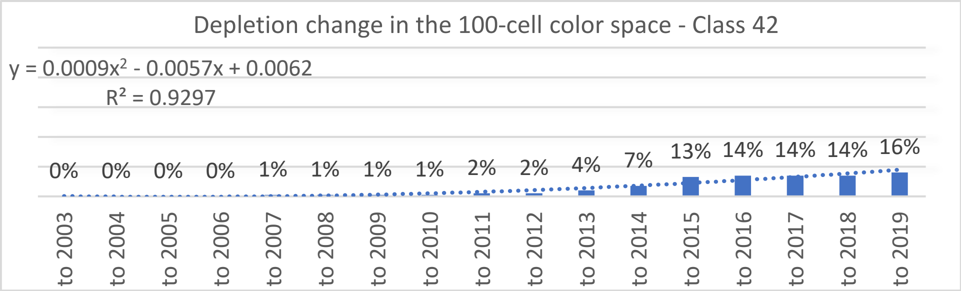


Chart 43. Depletion change in the 100-cell color space—Class 43. Given y = 1, x = 54.0172.

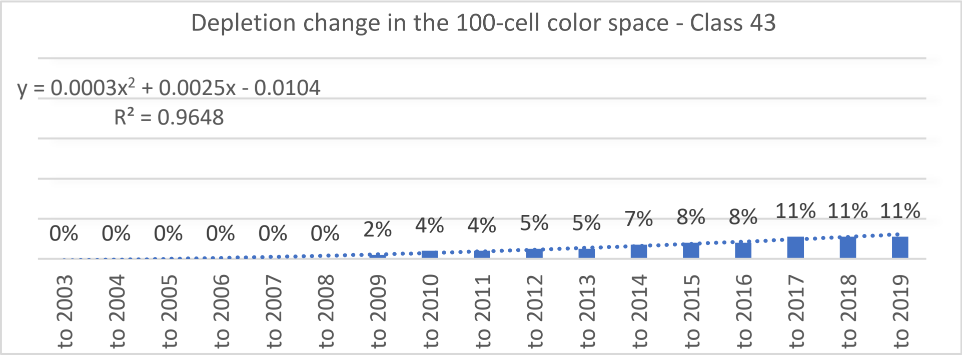


Chart 44. Depletion change in the 100-cell color space—Class 44. Given y = 1, x = 57.9422.

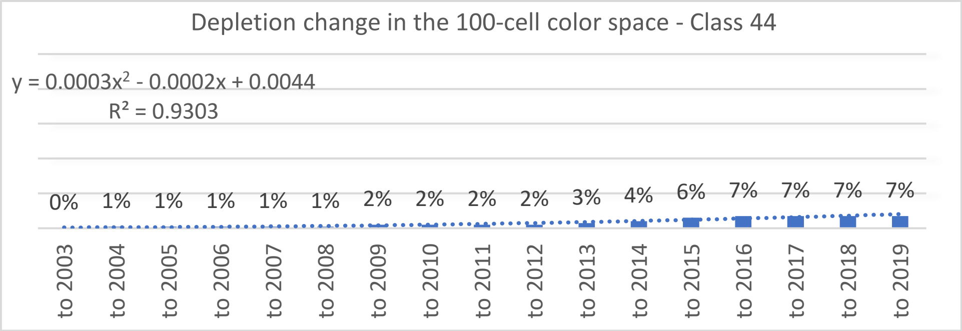
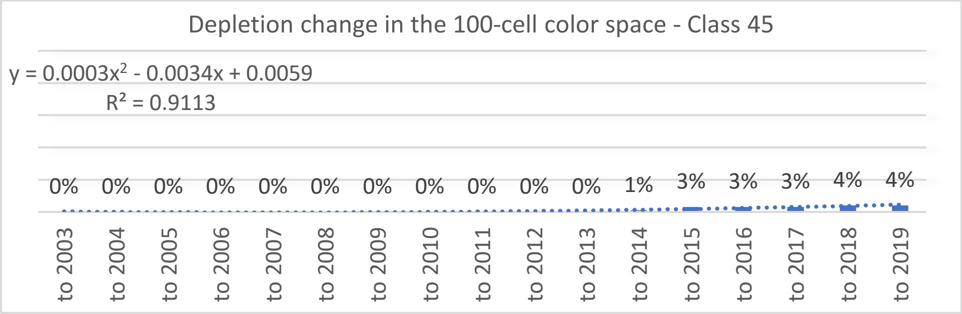


Chart 45. Depletion change in the 100-cell color space—Class 45. Given y = 1, x = 63.5094.



Appendix 6. The Two Patterns of Depletion Trend

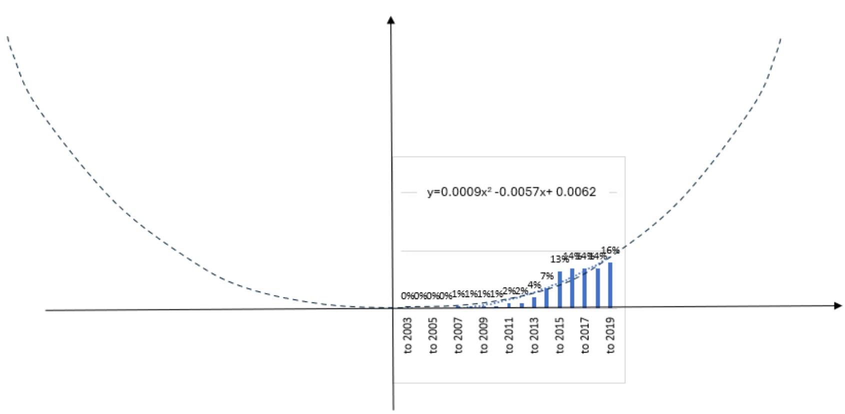
Based on the mathematic functions and curves of the annual depletion percentages in the forty-five classes of goods and services (Appendix 5), two general pattens of depletion trends exist:

Pattern 1: The depletion increases slowly at first, but accelerates later

Pattern 1 is that the depletion percentages increase slowly at first, but accelerate later, illustrated by Figure 13. Classes 3, 5, 8, 9, 10, 11, 12, 13, 14, 18, 20, 21, 24, 25, 26, 28, 29, 30, 31, 32, 34, 35, 36, 39, 40, 41, 42, 43, 44, and 45 share this pattern (check Appendix 5 for the specific pattern for each of these classes).

Take Class 42 as an example (Figure E, below), the trendline (depicted by the dashed line) shows that the depletion of Class 42 goes up slowly at the beginning, but accelerates later: the depletion grew by 2% from 2003 to 2011, but saw a more significant increase, escalating from 2% to 16% in the period from 2011 to 2019. The fitted mathematic function in Figure 13 shows that the whole curve is shaped as a U and the trendline of Class 42 locates at the upward right side of the U shape. This location suggests that the depletion in Class 42 will continue to accelerate after 2019. This acceleration also explains why Class 42 had a non-severe depletion percentage (16%) in 2019, but that it might be fully depleted before 2050.

Figure E



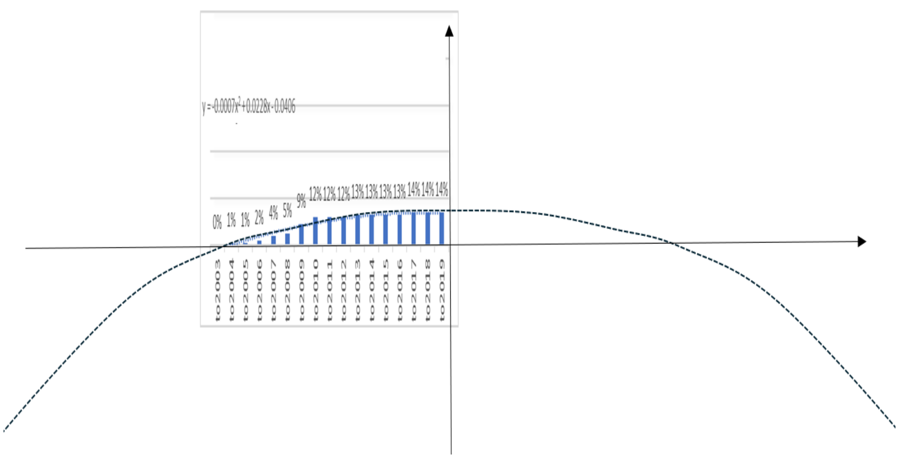
Why do these classes increase slowly but accelerate later? One interpretation lies in the development pattern of the industry related to each class. For example, Class 42 covers technical and computer services. The depletion pattern of Class 42, which increased slowly from 2003 to 2011, but accelerated quickly from 2011 to 2019, might be attributed to the rapid development in this sector since 2011. Verifying this association would require a separate project and is not the purpose of this article.

Pattern 2: The depletion increases quickly at first but flattens later, never reaching full depletion.

Figure 12 in the main text has dotted bars: Classes 1, 2, 4, 6, 7, 16, 17, 19, 22, 33, 37, and 38. These classes share Pattern 2, which increases quickly at first, but flattens later, illustrated by Figure F below. This pattern arises from the mathematical function describing the depletion percentage change over years.

Using Class 1 as an example, the trendline (represented by the dashed line) in Figure F initially exhibits a swift ascent, but gradually levels off. The fitted mathematic function in Figure F shows that the whole curve is shaped as an inverted "U."[5] The trendline of Class 1 is positioned just before and touching the peak point of the inverted "U" curve, where the depletion percentage is 14.5% in 2019. Therefore, the depletion trendline in Class 1 will touch the maximum depletion percentage 14.5% and go down later.

Figure F



The interpretation of Pattern 2 might be dependent on industry trends and development during 2003 to 2019, which would require separate research. Therefore, no attempt at interpretation is provided here.

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[5] The associated function also reflects this shape—a quadratic polynomial expressed as $y = -0.0007x^2 + 0.0228x - 0.0406$, with the first coefficient (-0.0007) being negative. This negative first co-efficient determines that the curve shape is an inverted "U."